

THURSDAY, JANUARY 20, 1876

THE "ENCYCLOPÆDIA BRITANNICA"

Encyclopædia Britannica. Vol. III. (Edinburgh: Adam and Charles Black.)

FIRST NOTICE.

THERE are several important scientific articles in this third volume which we shall briefly notice, the articles generally being quite up to the standard of the preceding volumes. In this first notice we shall refer especially to the articles "Birds" and "Biology." The former article is the joint production of two authors, Professors W. K. Parker and Alfred Newton.

Prof. Parker has undertaken the anatomical portion of the subject. Allowing himself to be led away in the direction of his favourite line of research, the author has persuaded himself that in the space allotted to him for his article "there is merely room for justice to be done to one category of organs; and as the skeleton and especially the skull is of most direct importance to the zoologist and palæontologist, and as its form determines, as it were, all other organs . . . it seems to be that on which election should fall for the fuller treatment." From this opinion we disagree *in toto*. If the space allotted for the subject is insufficient, it must be a fault of the general management of the "Encyclopædia." If the skull "determines, as it were," all other organs, then the study of anatomy is on a very different footing from that on which it seems to stand. By a glance at the earlier volumes of the work, in which, as in the case of the article "Anatomy," by Prof. Turner, apparently unlimited space is allowed to the author, we come to the conclusion that there is no fault in the editorial department, in this direction at least. As to the "determining" influence of the skull the true relationship of three groups of birds—the woodpeckers, toucans, and barbets—which will be found explained below, is quite sufficient to demonstrate how unwarranted is the assumption.

In 1867 Prof. Huxley propounded a classification of birds, not entirely, but mainly based on the nature of a portion of the palatal region of the skull. This valuable addition to ornithological and zoological literature has given a great stimulus to more minute investigation of avian structure. It brought to light many new facts, and placed prominently forward others previously too much neglected. The classification was, however, only an artificial one, for, according to that author's own words in the article "Biology" before us, "in an artificial classification some prominent and easily observed feature is taken as the mark of resemblance or dissemblance." The features employed in this case were two—the fusion or non-fusion of the maxillo-palatine plates of the maxillary bones, and the shape of the vomer. In a hobby-run-wild manner, Prof. Parker, in his article "Birds," has further elaborated this artificial arrangement to a degree which, more than anything else, demonstrates its untenability. He begins by dividing the "Carnatæ" into two sections, firstly, the Dromæognathæ (*Tinamous*), and secondly, all the others; because in the *Tinamous* the vomer is broad behind and interposes between the pterygoids, the palatines, and the basi-sphenoidal rostrum (which, however, is

also the arrangement in some of the penguins at least.) Among the other carinate birds, Prof. Huxley's divisions are retained, except that the woodpeckers are removed from the *Ægithognathæ* to form an independent group of equal importance with them, the *Saurognathæ*! The *Desmognathæ* (Huxley), we are told, do not form a well-collected group, and Prof. Parker does good service by indicating the different ways in which *desmognathism* may be produced.

According to this classification, there are some so great anomalies, when it is looked at from the aspect based on the totality of the morphological resemblances in the bird-class, that it is certain that the palate, *per se*, is in reality of secondary importance in the determination of the relationships of many birds.

For instance, according to Prof. Parker, the Woodpeckers (*Picidæ*) form a main division (*Saurognathæ*) of the non-*desmognathous* carinate birds, at the same time that the Toucans (*Ramphastidæ*), together with the Barbets (*Capitonidæ*) form part of a minor section (*Coccygomorphæ*) of the *desmognathous* birds. In other words, they would be made to have as little to do with one another as they well can. Now the structure of the rest of the body, other than the head, tells quite a different tale. From the form of the feathers and the pterylosis, there being no after-shaft, a tufted oil-gland and quite a characteristic distribution of the peculiarly narrow feather-tracts; from their osteology, the sternum and other bones being almost identical in all of them; from the anatomy of the alimentary canal, in which the colic cæca are absent; from the arrangement of the toes in the scansorial foot; from their myology, in which they are identical when dissected, muscle by muscle, and different in points from all other birds, it is certain that the three groups, viz., the Woodpeckers, Barbets, and Toucans, are most intimately related, and have not, in reality, a family difference between them; their dissimilarities—the Toucans and Barbets merging into one another—leading to their being arranged in two sub-families.

As another example of the different teaching of the artificial and the natural classifications, the Swifts (*Cypselidæ*) and the Humming Birds (*Trochilidæ*) may be referred to. These two groups, from the details of their internal structure when examined one by one, are most certainly related as intimately as are the Woodpeckers with the Toucans. There is, in fact, not a family difference between them, and yet, from their palates, Professors Huxley and Parker place them in quite different divisions, because the vomer is truncated in the one and pointed in the other.

We think that we have said enough to show that the structure of the skull does not alone suffice to determine the mutual affinities of birds, the head in them being subject to rapidly developing peculiarities which are associated with their habits of life.

With the exception of the skeleton, the rest of which is described in fair detail, Prof. Parker devotes but few columns of his article to the organs, muscles, vessels, and nerves; he in most cases quoting verbatim from Prof. Huxley's "Anatomy of Vertebrated Animals."

Prof. Newton's portion of the article "Birds" forms a valuable memoir on the topics he discusses. The elegance of the style, and the careful manner in which the

relative importance of the facts which are introduced is weighed, adds a charm to the subject equal to that which it already possesses. "Fossil Birds," "Sub-fossil Birds," "Birds recently extirpated," "Birds partially exterminated," "The Geographical Distribution of Birds," "Migration," "Song," "Nidification," "Eggs," and "Moult," are the headings of the various sections of his subject; the whole occupying about fifty pages of the "Encyclopædia;" that on Distribution being of considerably the greatest length, as it is fairly exhaustive in its account of the avifauna of the different regions. Speaking of the general principles of zoogeography, first laid down by Mr. Sclater in 1857, Prof. Newton remarks that "without infringing upon what must be deemed the generalities of biological distribution, it is proper to observe that Mr. Sclater's success is to be attributed to the method in which his investigations were carried on—a method in which he had but few predecessors. Instead of looking at the earth's surface from the point of view which the geographer would take of it (a point of view which had hitherto been adopted by most writers), mapping out the world according to degrees of latitude and longitude, determining its respective portions of land and water entirely regardless of the products of either element, or adhering to its political divisions—time-honoured as they were—he endeavoured to solve the question simply as a zoologist should, by taking up the branch of the subject with which he was best acquainted, and by pointing out and defining the several regions of the globe in conformity with the various aspects of ornithic life which they present. But herein there was at once a grave difficulty to be encountered. Birds being of all mammals most particularly adapted for extended and rapid locomotion, it became necessary for him to eliminate from his consideration those groups, be they large or small, which are of more or less universal occurrence, and to ground his results on what was at that time commonly known as the order *Incessores*, or *Passeres*, comprehending the orders now generally differentiated as *Passeres (vera)*, *Picaria*, and *Psittaci*. On this basis, then, Dr. Sclater was enabled to set forth "that the surface of the globe exhibited six great regions," an account of each of which is given in detail, with the light thrown upon them by more modern research.

As might be imagined, the section on "Birds recently extirpated" is a more complete and accurate *résumé* of their history than any other extant, the Starling of Réunion (*Fregilupus varius*), the Solitaire of Rodriguez (*Pezophaps solitarius*), and the Crested Parrot of Mauritius (*Lophopsittacus mauritianus*), being figured as well as described.

The article "Biology" is by Prof. Huxley and Mr W. T. Dyer. The subject is treated generally by the former author in his well-known style, whilst Mr. Dyer gives the principles of classification of the vegetable kingdom as they are now understood by the most advanced botanists.

Prof. Huxley classifies the phenomena of life under four headings:—1. Morphology; 2. Distribution; 3. Physiology; and 4. Etiology. The last of these, from its theoretical nature, presents features of more especial interest. With reference to the doctrine of spontaneous generation we read: "It has been pointed out at the

commencement of this article that the range of high temperatures between the lowest, at which some living things are certainly killed, and the highest, at which others certainly live, is rather more than 100° Fahr. It makes no sort of difference to the argument how living beings have come to be able to bear such a temperature as the last mentioned; the fact that they do so is sufficient to prove that, under certain conditions, such a temperature is not sufficient to destroy life. . . . Thus it appears that there is no ground for the assumption that all living matter is killed at some given temperature between 104° and 208° Fahr." Again, "it is argued that a belief in abiogenesis is a necessary corollary from the doctrine of evolution. . . . In the eyes of a consistent evolutionist any further independent formation of protoplasm would be sheer waste."

Prof. Huxley gives his powerful and entire sanction to the doctrine of Ontogeny, explaining the facts that in many forms there are gaps and irregularities in the order of production of the organs, by assuming that the series of developmental stages of the individual organism never present more than an abbreviated and condensed summary of ancestral conditions.

Mr. Dyer devotes himself to the "Limits and Classification of the Vegetable Kingdom," and concludes his article with a synoptic view of the relations of plants, which shows how much attention has recently been paid to the lower forms. Schwendener's hypothesis is assumed, and "Lichens must now be regarded as composite structures, partly consisting of an alga, partly of a fungus." The Thallophyta are classified according to the method of Sachs, and the Cryptogams according to Cohn. The stepping-stones between these last and the Phanerogams are excellently sketched.

We think we have said enough to show the great importance of the two articles which we have been attempting to criticise.

A. H. GARROD

FOSSIL BUTTERFLIES

Fossil Butterflies. By Samuel H. Scudder. (Published by the American Association for the Advancement of Science, Salem, 1875.)

THE memoir now before us will be a boon, not only to geologists, but to entomologists, inasmuch as it reproduces in a small compass, as Mr. Scudder says, "all that has been published of this group of fossils, whether of text or illustration."

After giving a complete list of all the works treating of the subject, the author proceeds to characterise the genera and species, beginning with *Neorinopsis sepulta*, from Aix in Provence, a fossil more discussed than any other ancient Lepidopteron. He confirms Mr. Butler's determination of its affinities, but adds that, from a careful study of the original, he has been enabled to correct an error as regards the actual condition of the fossil, which he thus describes:—

"The thorax, hind legs, and both pair of wings of the left side are preserved, almost completely; all the rest is lost. The thorax is viewed from above, and somewhat on the left side; the hind coxæ seem to be almost torn away from their immediate connection with the trunk. The two hind legs are stretched out, bent at the femorotibial articulation; the left leg lies above both the wings,

and is apparently attached throughout, although its base is covered a little by the crushed body; the right leg lies below both the wings, and is apparently partially detached, though but slightly, from the coxæ; the tibio-tarsal articulation can be distinguished, but not the tarsal joints. The wings are bent over downward in a position the reverse of that of repose. The fore-wing covers the hind-wing, as in nature, but to such an extent as to conceal the greater part of it; the guttered portion of the inner margin of the hind-wings is almost fully expanded, but apparently has a fold next the submedian nervure. The fringe of the fore-wing seems to be gone, but that of the hind-wing is preserved nearly throughout. Head, fore and middle legs, wings of the right side, and abdomen are wholly wanting.

"The upper surface of the wing is, therefore, the part which attracts most attention."

The above description throws an entirely new light upon this fossil, and is exceedingly interesting.

Lethites reynesii, another Eocene species, is placed next to the genus *Lethe*; the latter comes close to *Melanitis* in Westwood and Hewitson's "Genera of Diurnal Lepidoptera," a fact which Mr. Scudder considers of some interest; the two groups, however, are widely separated in some recent classifications, in which the structural relations of the genera of *Satyrinae* have received special attention.

The Tertiaries of Radoboj afford another remarkable fossil (*Mylothrites pluto*) which Mr. Scudder, differing widely from all previous writers, refers, on we think insufficient grounds, to the sub-family *Picrinae*, inasmuch as the spots on the wings are not of the same simple character as those of *Hebomoia* and allies, but are true ocelli, the zones of which are clearly visible even in the drawing on Plate II. (compare Figs. 14 and 17). The portion of a hind wing (Fig. 15) has been also somewhat rashly referred to *Mylothrites*, its venation being markedly different, and agreeing more nearly with the Eastern genus *Terinus* than with any other group known to us.

Mr. Scudder seems to have indicated the correct position of *Coliates proserpina* and *Pontia Freyeri*. In the case of the former, his task, owing to the obscure character of the original, must, as he says, have been a difficult one.

Spots on the wings, such as are represented on Plate II., Fig. 5, are rarely to be met with among the *Picrinae*, but do occur in some males of the genus *Appias*.

It is probable that Mr. Scudder is again correct with regard to the position of *Thaites ruminiana*, although the general pattern, form of the wings, and large abdomen are all far more like *Dynastor* or *Castnia*.

Thanaites vetula and *Pamphilites abdita* have manifestly the proper places assigned to them, and great credit is due to the author for the labour which he has expended in their determination.

Mr. Scudder's conjectures respecting the "food-plants of Tertiary Caterpillars" are exceedingly interesting, as also his remarks on "the present distribution of Butterflies most nearly allied to fossil species." Asiatic forms having the facies of *Pamphilites abdita* are not, however, as he supposes, unknown; the *Urbicola* of East India are perhaps not as yet largely represented in American collections.

In his "Notice of Insects which have been erroneously referred in recent times to Butterflies," Mr. Scudder

dwells upon the discussion between himself and Mr. Butler respecting *Palaontina oollica*, and gives facsimiles of that author's illustrations, with an additional sketch representing his own view of the characters of the species. From a comparison of the five illustrations it is difficult to conclude that Mr. Scudder has proved his case. The venation, as given by him, not only does not agree with that of any genus of *Lepidoptera*, but is entirely at variance with what is found in any insect. To associate it with the *Cicadine* is impossible, seeing that these insects have irregular neurulation, whereas Scudder's figure furnishes us with a Lepidopteroid type having anomalous cross-veins and an incomprehensible discoidal cell.

The assertion that "none of the median nor any of the inferior subcostal nervules are ever branched certainly requires modification; the genus *Amathusia* has a well-marked spur on the third median branch, which conveys the impression of a fourth median nervule, whilst the genus *Moschoneura* emits its upper discoidal from the inferior margin of the subcostal.*

Mr. Scudder, in America, is surely a little too hard upon his entomological brethren on this side of the Atlantic, when he speaks of the new Linnaean room at Burlington House in which they held their meeting as "a poorly lighted hall." See p. 95.

We cannot conclude without expressing our admiration of the beautifully executed plates which accompany the letterpress.

BURCHETT'S "PRACTICAL PLANE GEOMETRY"

Practical Plane Geometry. By E. S. Burchett. (London and Glasgow: W. Collins, Sons, and Co., 1876.)

THIS is a carefully got-up and good work on the subject of which it treats. After the usual preliminary matter on definitions and the use of instruments are given 333 problems. This may appear to be too large a number for school teaching, but the work is principally intended for students in Art schools. For school purposes, and we have more than once recently pointed out that the subject is taught as affording a good initiation to the study of pure geometry, we should recommend the master to make a selection such as he thinks adapted to the attainments of his pupils or fitted to the end he has in view in taking up the study. Plates LII. to LXIII. are devoted to Applied Geometry (such as curves of mouldings, Gothic tracery, construction of scales, &c.). An Appendix (Plates LXIV. to LXXI.) treats of the Elements of Orthographic Projection. This last portion we are told is given expressly to meet the requirements of the more extended range of the Second Grade Examination of the present day. We have verified most of the constructions, which are clearly given, and in the main admit of demonstration on pure geometric principles. Some relating to the construction of polygons, three on the contact of circles, and some few relating to the areas of circles, are founded on approximative methods. The arrangement of the text and of the plates appears to us to be a good one. The book must be used in a position at right angles to the usual one, and then the text is on

* See Westwood's "Oriental Entomology," p. 40, and compare "Trans. Ent. Soc.," 1870, p. 426; also "Cistula Entomologica," i. p. 54.

the left-hand page, and so above the plates, which are immediately under the pupil's eyes. The printing and the plates (the only figure that does not please us is the oval on Plate II.) leave nothing to be desired.

We proceed to point out a few matters which we think admit of improvement. Plate II. in the definition of a circle *invariant* is used; why not "constant?" The construction of Fig. 6 (Plate IV.) is hardly satisfactory to our view, though it is one very frequently given; the tangent to the two arcs is not obtained by a legitimate method. We cannot make out the definition of an harmonic mean given on Plate VII., but the means are correctly constructed. In Fig. 31 (text), for GH:HA, read *vice versa*. We may remark that it is a curious fact that the approximative construction given in Fig. 87 is true in the cases of regular figures of three, four, and six sides. In Fig. 99 (text) read "through F and E." In Fig. 112 (text) arcs "cutting in C," not G. Constructions to Figs. 123, 125 give particular ellipses; so in the case of the parabolas in Figs. 138, 139, we note that certain figures are stated to be co-centric and certain curves have asymptotes. In Fig. 271 (text) read to cut in "I and H." We object, on pure geometric grounds, to the constructions in Figs. 278, &c., where a line is found equal to the semi-circumference of a circle, &c.; also the inscribed circle of a square and the inscribed triangle are stated as being in the ratio, triangle : circle : square, as 2 : 3 : 4. In Fig. 279 (text) the two last A's should be D. The construction to Fig. 297 (to draw a line to bisect any triangle from a given point within it) is new to us, and on a cursory examination of it we have not satisfied ourselves of its correctness. In Fig. 314, for XY, read ZV. In Fig. 316, "the square on," or some such words have been omitted. In Fig. 323 the limitations have not been laid down. In Fig. 329, "join point x," &c.; in 331, for "rectangle" read "parallelogram." These trivial oversights will serve to show how correctly the text has been printed.

OUR BOOK SHELF

Observaciones Magneticas y Meteorologicas del Colegio de Belen de la Compania de Jesus en la Habana, 1873 y 1874. (Habana, 1874 and 1875.)

THE observations made at the College of the Society of Jesus, Havana, are peculiarly valuable for the fulness and care with which they are made, and for the completeness with which the observations themselves and the monthly means and extremes are given in each monthly table and its accompanying diagram. The diagrams, which have been published in their present improved form since June 1873, and which exhibit on one sheet the two-hourly observations as made daily from 4 A.M. to 10 P.M. of all the meteorological and magnetical elements, will very much facilitate the study of those inquiries which deal with the inter-relations of these elements. To these observations are added the daily amounts of the rainfall and evaporation—the latter being of great interest as contributing to our knowledge of the evaporation in inter-tropical regions, of which so little is known. Whilst only the daily amounts of the rainfall is given, each hour during which rain falls is noted, together with the hour of occurrence of thunder and other irregularly recurring phenomena. As regards the diurnal variations of the wind it changes from about S.E. in the early morning, through E. and N.E. to N.N.E. its most northerly point, which is usually reached about 2 P.M., and thence in the

reverse direction through N.E. and E. to E.S.E., which is reached about 10 P.M. The diurnal velocity is at the minimum at 4 A.M., rises to the maximum at 2 P.M., and thence falls steadily to the minimum. The N. and N.E. winds are decidedly the strongest, and the S.E. the weakest, the ratio being as two to one; in other words, the sea-breeze blows with double the velocity of the land-breeze at this station.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.]

Blowpipe Analysis

MR. HUMPIDGE (vol. xiii. p. 208), on the entirely gratuitous assumption that I use "commercial reagents"—whatever that term may mean—says that there is probably iron in my soda.

To this I only reply that I will undertake to show pyrologically the presence of 0.01 per cent. of iron oxide in a fragment of a salt the size of a pin's head; and that, when Mr. Humpidge can do as much without using the dangerous test potassium ferrocyanide (which itself contains iron), I will admit his right to assume that he knows his tools better than other workmen.

No one has ever doubted the proportional relativity in precipitating power between a drop and a gallon of water, but if Mr. Humpidge will only do me the justice not to mutilate my statements in the reproduction, he will repeat that a precipitate could not be shown in a drop of water "on a fused mass upon an aluminium plate."

Shepherd's Bush, W., Jan. 14

W. A. Ross

The D-line Spectrum

WILL Prof. Stokes give us the reason of his now holding that his first—to all appearance, extremely rational—conclusion, that, in consequence of "the powerful affinities of sodium, it could not exist in a free state in the flame of a spirit-lamp," is "erroneous?"

Shepherd's Bush, W., Jan. 8

W. A. Ross

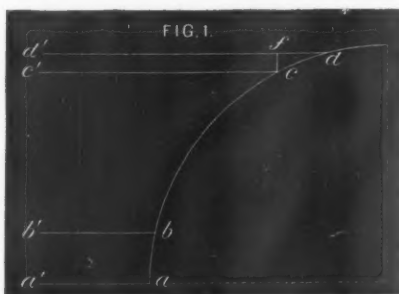
The Difference of Thermal Energy transmitted to the Earth by Radiation from different parts of the Solar Surface.

THE tenor of certain letters received from scientific persons on the above subject induces me to lay the following statement before the readers of NATURE:—

1. Previous to undertaking a systematic investigation of the mechanical properties of solar heat, I examined thoroughly the merits of Laplace's famous demonstration relating to the absorptive power of the sun's atmosphere, proving that only one-twelfth of the energy developed by the sun is transmitted to the earth. The demonstration being based on the assumption that the sun's rays emit energy of equal intensity in all directions, my initiary step was that of testing practically the truth of that proposition. It has been asserted that Laplace did not propound the singular doctrine involved in such a proposition, I therefore feel called upon, before proving its unsoundness, to quote the words employed by the celebrated mathematician. (See "Mécanique Céleste," tome iv. page 284.) Having called attention to the fact that any portion of the solar disc as it approaches the limb ought to appear *more brilliant* because it is viewed under a *less angle*, Laplace adds:—"Car il est naturel de penser que chaque point de la surface du soleil renvoie une lumière égale dans tous les sens." Let *abcd*, in the annexed diagram, Fig. 1, represent part of the border of the sun, and *ba*, *cd*, small equal arcs; *ad*, *bc*, *cd*, *dd'*, being parallel rays projected towards the earth. Laplace's theory asserts that owing to the concentration of the rays the radiation emanating from the portion *dc* transmits *greater* intensity towards the earth than *ba*, in the proportion of *cd* to *ba*. The proposition is thus stated in "Mécanique Céleste": "Call θ the arc of a great circle of the sun's surface, included between the luminous point and the centre of the sun's disc, the sun's radius being taken for unity; a very small portion *a* of the surface being removed to the distance θ

from the centre of the disc, will appear to be reduced to the space $a \cos \theta$; the intensity of its light must therefore be increased in the ratio of unity to $\cos \theta$.

2. In order to disprove the correctness of the stated demonstration, I have measured the relative thermal energy of rays projected in different directions from an incandescent metallic disc, by the following method:—Fig. 2 represents section of a conical vessel covered by a movable semi-spherical top, the vessel being surrounded by a jacket through which water may be circulated. A revolving circular disc, aa , composed of cast iron, the back being semi-spherical and protected by fire-clay, is suspended across the top of the conical vessel supported by horizontal journals attached at opposite sides. The angular position of the disc is regulated by a radial handle, b , connected to one of the journals; the exact inclination to the vertical line being ascertained by means of a graduated quadrant, d . An instrument, c , capable of indicating the intensity of the radiant heat transmitted by the incandescent disc, is applied at the bottom of the conical vessel. The mode of conducting the experiment is extremely simple. The movable cover and its lining of fire-clay having been removed, the cast-iron disc is heated in an air-furnace to a temperature of $1,800^\circ \text{F}$. It is then removed by appropriate tongs, and suspended over the conical vessel, the lining and cover being quickly replaced. The temperature, shown by the instrument at the bottom of the conical vessel, resulting from the action of the radiant heat of the disc, is then recorded for every tenth degree of inclination. The investigation, it may be briefly stated, shows that the temperatures imparted by radiation to the recording instrument is exactly as the sines of the angles of inclination of the disc. Hence, at an inclination of 10° to the vertical line, the temperature imparted to the thermometer is scarcely one-sixth of that imparted when the disc

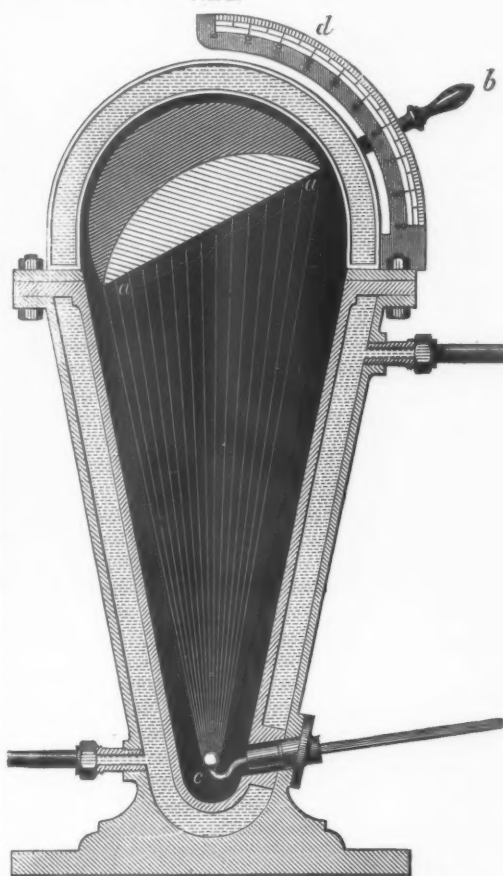


faces the thermometer at right angles; yet in both cases an equal amount of surface of an equal degree of incandescence is radiating towards the instrument! Laplace and his followers have evidently overlooked this important and somewhat anomalous fact, proving that radiation emanating from heated bodies is incapable of exerting full energy in more than one direction. Our practical experiments with the revolving incandescent disc have thus fully demonstrated the truth of the proposition intended to be established, namely, that the rays emanating from incandescent planes do not transmit heat of equal energy in all directions, the energy transmitted being as stated, proportionate to the sines of their angle of inclination to the radiating surface.

3. The next step in the investigation of solar heat, before adverted to, was that of measuring the radiant energy transmitted in a given direction by an incandescent solid metallic sphere. For this purpose I employed a double conical vessel similar to the one represented in Fig. 2, the incandescent sphere being suspended over the conical vessel in the same manner as the revolving disc. The nature of the arrangement will be readily understood by inspecting the annexed diagram, which represents four spheres, Figs. 3, 4, 5, and 6, each sphere being divided into four zones, A, B, C, and D, occupying unequal arcs, but containing equal convex areas. Semi-spherical screens composed of non-conducting substances were applied below each sphere, provided with annular openings, arranged as shown in the diagram. Through these annular openings the radiant heat from the incandescent zones, D, C, B, and A, was transmitted to the thermometers, f , g , h , and k , respectively. Père Secchi, and other followers of Laplace, will be surprised to learn that when the suspended sphere was maintained at a temperature of $1,800^\circ \text{F}$, the radiation from the zone C, Fig. 4, imparted a

temperature of $27^\circ.49 \text{ F}$. to the thermometer g , while the radiation from the zone A, Fig. 6, imparted only $6^\circ.19 \text{ F}$. to the thermometer k . Let us bear in mind that the radiating surface lm of the zone A is equal to the radiating surface pq of the zone C. The stated great difference of temperature produced by the radiation from zones of equal area furnishes additional proof that Laplace based his remarkable analysis on false premises. "The sun's disc ought to appear more brilliant towards the border, because viewed under a less angle," we are told by the great analyst. The instituted practical tests, however, prove positively that the energy of the rays projected from the border of an incandescent sphere is greatly diminished because viewed under a less angle from the point occupied by the recording thermometer.

FIG. 2.



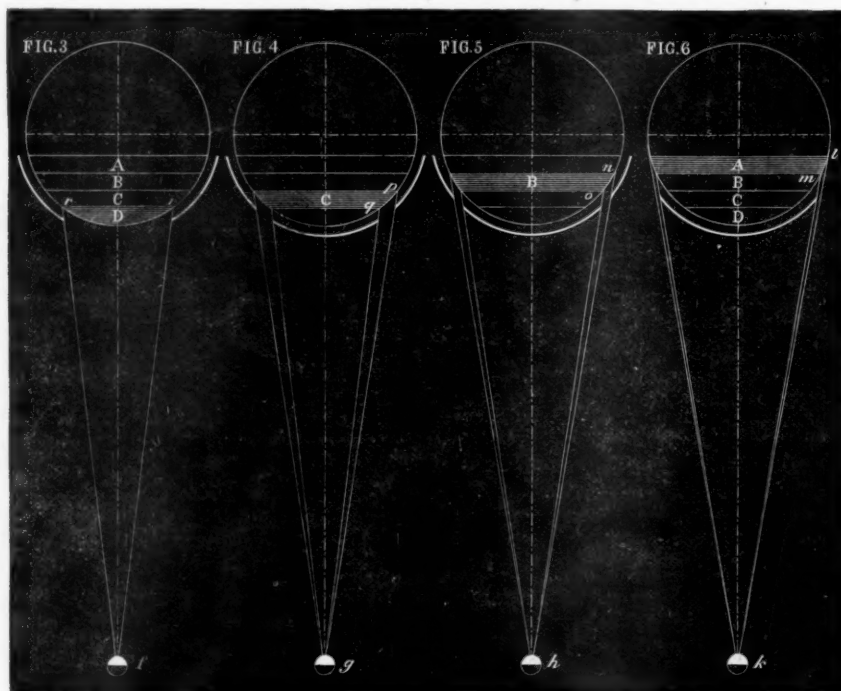
4. The result of our experiment with the revolving incandescent disc shows that if the small arc ba , in Fig. 1, be reduced until the field represented by $\theta a'$ becomes equal to the field represented by $\epsilon' d'$, the radiant energy transmitted through each of those fields will be alike; the reason being that the number of rays of diminished intensity passing through $\epsilon' d'$ will be as much greater than the number of rays of maximum intensity passing through $\theta a'$, as cd is greater than the reduced $ba = fc$. It should be observed that cd is so small that we may without appreciable error regard it as a straight base, and fc as the sine of the angle cdf . It follows from this demonstration that if the solar atmosphere exerted no retarding influence, the radiant heat transmitted towards the earth would be alike for equal areas of the solar disc—more correctly, for areas subtending equal angles, since the receding part of the solar surface is at a greater distance from the earth than the central part.

Encouraged by the practical result of the instituted investiga-

tion, I devised the method described in NATURE (vol. xii. p. 517), showing that the polar and equatorial regions of the solar disc transmit radiant heat of equal intensity to the earth, and that the sun emits heat of equal energy in all directions. Adopting Secchi's doctrine relating to the retardation suffered by calorific rays in passing through atmospheres, viz., that the diminution of energy is as the depth penetrated by the rays, it may also be shown by an easy calculation based on the result of our investigations, that the absorption by the solar atmosphere cannot

exceed one-seventh of the radiant energy emanating from the photosphere.

5. Concerning the plan resorted to by the Director of the Roman Observatory, and others, of investigating the sun's image instead of adopting the method of *direct* observations, I will merely observe that the information contained in the several works of the Roman astronomer furnishes the best possible guide in judging of the efficacy of *image investigation*. Let us select his account of the investigations conducted between the



19th and 23rd of March, 1852. Having pointed out that in these experiments it was impossible to approach within a minute of the edge of the sun, and that during a later observation—date not mentioned—he had approached within a minute, the investigator observes: "But at this extreme limit, even making use of the most accurate means of observation, we find difficulties which it is impossible to overcome completely." In addition to this emphatic expression regarding the difficulties encountered, the author adds: "Moreover, it is impossible to study the edge alone, for the unavoidable motions of the image do not admit of its being retained at exactly the same point of the pile; we have therefore been unable to push the exactness as far as we hoped; and we have discontinued the pursuit of these researches, although the results obtained are quite interesting." (See revised edition of

"Le Soleil," vol. i. p. 205.) It is needless to institute a comparison between a system of which its founder speaks so despondingly, and one which enables us to push our investigations to the extreme limit of the solar disc, admitting of entire zones being viewed at once, instead of only small isolated spots.

J. ERICSSON

The Glow-worm in Scotland

THE Glow-worm is not uncommon on the Island of Cumbrae, Buteshire. I have seen it there occasionally for the last thirty years (see vol. xiii. pp. 188, 208).

DAVID ROBERTSON

Millport, Island of Cumbrae, Jan. 18

OUR ASTRONOMICAL COLUMN

STAR WITH SUSPECTED LARGE PROPER MOTION.—It would appear by a communication from Prof. Winnecke, Director of the Imperial Observatory at Strasburg, that the large proper motion exhibited by a comparison of Argelander's positions of the ninth magnitude star, No. 11237-8 of Oeltzen's catalogue (southern zones) with Taylor's observations at Madras in 1838 or 1839, to which reference was lately made in this column, does not really exist, there being evidently an error in Taylor's mean place for 1840 given at p. clxiii. of vol. v. of the Madras Observations. Prof. Winnecke finds that the differences of right ascension and declination between this star and Oeltzen 11226, are sensibly the same as at the time of Argelander's observations (1851), and the latter star is known to have but very small, if any, proper

motion. Taylor's star must therefore be struck off the list of cases of great proper motion lately given.

ATLAS - 27 f PLEIADUM.—A very interesting observation was made at Strasburg on the occasion of the occultation of this star—a Struve's *difficillima*—on the 7th of the present month. As we recently stated, this star does not appear to have been seen double since the last Dorpat observation in 1830. On the 7th inst., however, Herr Hartwig observing at Strasburg with an excellent Fraunhofer, of 42 lines aperture, power 159, remarked that the star did not disappear instantaneously; after the principal mass of light had vanished there remained a luminous point for about six-tenths of a second, a circumstance which favours the duplicity of the object, notwithstanding the failure of recent efforts to divide it. It brings to our recollection Burg's observation of the

occultation of Antares 1819, April 13, when at emersion the star appeared to suddenly increase from one of the sixth or seventh magnitude to one of the first, a phenomenon no doubt attributable to the existence of the small companion on the parallel, preceding the principal star (NATURE, vol. xii. p. 308).—The next occultation of Atlas-Pleiadum, on February 3, will not be visible in this country, but may be well observed in the United States. The American Ephemeris gives the time of immersion for Washington; at the Observatory of Hamilton College, Clinton, N.Y., so actively conducted by Prof. Peters, the immersion takes place at 11h. 13m., and the emersion at 12h. 4m., Clinton M.T.

VARIABLE STARS.—In No. 2071 Dr. Julius Schmidt, of the Observatory, Athens, continues his elaborate researches on the three short-period variables U, W, and X Sagittarii, the periods of which are now given thus:—

	d.	h.	m.	s.
U Sagittarii	6	17	53	1.4
W = γ Sagittarii	7	14	15	34.1
X = 3 Flam.	7	0	17	42.5

So assiduously have these stars been watched by their discoverer, Dr. Schmidt, in the fine skies of his locality (little success could be expected to attend their observation in England), that he believes he has detected perturbations of the light curve or period in each instance, though not quite ten years' observations are yet upon record.

The following are Greenwich times of geocentric minima of Algol, according to Prof. Schönfeld's elements:—

	h.	m.		h.	m.
1876. Feb. 2	18	37	1876. Feb. 25	17	11
5	15	26	28	14	0
8	12	15	March 2	10	49
11	9	4	5	7	39
14	5	54			

Similar times of geocentric minima of S Cancri, according to Prof. Schönfeld, are:—

	h.	m.		h.	m.
1876. Jan. 29	13	46	1876. April 14	10	54
Feb. 17	13	2	May 3	10	12
March 7	12	19	22	9	31
26	11	36			

RECENTLY-DISCOVERED MINOR PLANETS.—No. 152, discovered at Paris by M. Paul Henry on Nov. 2, has been named *Atala*, and for No. 157, the small planet, detected by M. Borrelly at Marseilles on Dec. 1, the name of *Dejanira* is proposed; elements of this planet have been calculated by M. Stephan. The following are first approximations to the positions of the ascending node, inclination, and periods of the newer minors, with dates of discovery:—

No.	Ascending Node.	Inclination.	Period in years.	Date of discovery, 1875.
150	207 55	0 2	5.16	Oct. 18
151	40 2	7 52	4.15	Nov. 1
152 (<i>Atala</i>)	41 29	12 10	5.54	Nov. 2
153 (<i>Hilda</i>)	228 20	7 45	7.84	Nov. 2
154	37 35	20 49	5.78	Nov. 4
155	40 16	8 52	Circular elements	Nov. 8
156	246 11	7 29	5.29	Nov. 22
157 (<i>Dejanira</i>)	62 25	11 50	4.16	Dec. 1

[Since the above was in type No. 158 is announced in the *Berlin Circular* and *Leverrier's Bulletin International*, as having been discovered at the Observatory of Berlin, by Herr V. Knorre, on the morning of the 5th inst., in R.A. 7h. 19m. 58s., and N.P.D. 67° 58'. Magnitude 11-12.]

THE NEW MUSEUM OF THE GEOLOGICAL SOCIETY

WHEN it was first announced to the Council of the Geological Society that the Government proposed to offer a suite of rooms in Burlington House in lieu of

the apartments the Society occupied in Somerset House, it was at once seen that the most formidable work the change involved would be the removal of the collections of minerals and fossils. The transference of the library, though an extensive one, would be a comparatively easy matter, but there is always the danger in the mere handling of fossils that they may be damaged. Besides this, the collection had gradually grown to such a size that it was evident the cost of the removal would be considerable. So far as the preparation of the rooms at Burlington House was concerned, the Government showed every desire to conform as far as possible to the wishes of the Council.

Some of the Fellows counselled that the whole collection should be offered to the British Museum or to the School of Mines Museum in Jermyn Street, on the ground that though in the early days of the Society it was of high value when it was the only museum that existed, it was now so far surpassed in magnitude by the national collections that it was practically of small value. Fortunately wiser counsels prevailed. There were in the museum, it was urged, many typical collections formed by the early leaders of geological science, which were bequeathed in illustration of papers they had read and work they had done. These collections, obtained by their own personal labour in the field, arranged and named in their own handwriting, were of historical value and had a European reputation, and ought to be religiously preserved by the Society. It was true that the integrity of some of the collections had been destroyed in the endeavour at one time to make one general collection illustrating the whole of England, and arranged in stratigraphical order; but in most cases the original labels and references to catalogues were preserved, and it was hoped it might be possible in the new buildings to regroup the specimens much as they were at first. It was therefore determined that the museum should be maintained, not as a general geological collection, but mainly as a repository of specimens referred to in papers, and that before the removal commenced it should be carefully weeded, so that in all cases where, through the accidental removal of a label or other causes, the history of any specimen had been lost, it should be discarded, but not until every effort had been made to try to ascertain any possible clue. This work has been carried out by Prof. Rupert Jones, aided by Mr. Woodward, the assistant curator. The accumulation of specimens had caused much crowding in the museum, and in such a case a certain amount of damage and loss of labels was almost inevitable. As a consequence of this weeding, many specimens have been omitted in the new arrangement, and the result has been to leave greater space for those that have a real historic value.

Like many other institutions of gradual growth, the history of this museum has never been written, and very few people, few even of the Fellows of the Society, know what it contains, for there never has been a printed catalogue. As the collections are the private property of the Society and are not open to the public, this perhaps has not been thought requisite.

Among the principal collections preserved which have now historic value, first in point of general interest should perhaps be mentioned the extensive series of fossils presented by Sir Roderick Murchison, from which were drawn the figures in his world-renowned "*Siluria*." The fossils figured in the papers by Murchison and Sedgwick in describing the structure of Wales and the Lake district are also there, so are the fossils that illustrated Murchison's description of Brora. The fossils connected with Webster's well-known paper of 1814, the first paper on the Tertiaries of Hampshire; most of those illustrating Fitton's celebrated paper on the "*Strata below the Chalk*" (1827); those belonging to Buckland and Conybeare's comprehensive paper "*On the South-west of England*" (1824) are all there. Large additions to the general col-

lection were also made by Dr. Mantell, Dr. Macculloch, and Mr. Leonard Horner.

It will be recollected that the Society was originated in 1807, at a time when mineralogy was a fashionable study, or at least when collections of minerals formed part of the "furniture" of the apartments of the Queen and many of the nobility. Collections of shells and of fossils were also fashionable, but they were valued only for their beauty or their rarity, and not for any knowledge of nature they afforded. For some time the young society seems to have followed fashion. Indeed, the value of fossil organic remains as giving a clue to the consecutive sequence and relative order of strata was then but just beginning to be understood. It was not till the end of 1799 that the first MS. table of the sequence from the Carboniferous beds upwards was constructed, and no map of the strata of England was published till 1815. The earliest MS. catalogue of specimens belonging to the Society, begun in 1808 or 1809, is labelled "General Catalogue of Minerals," and some of the early entries of organic fossils refer rather to the rock in which the fossil is imbedded; the presence of the fossil being but casually noticed, such as "limestone containing shells." These early collections of fossils illustrating the labours of the first geologists in using organic remains to trace the chronological sequence of beds, and to compile some chapters of the earth's history, have a profound interest, laying as they did the foundations of a science which has placed at rest many wild theories of the origin of the earth, and has, too, proved to be of such practical value. The first donation recorded is Feb. 5th, 1808, of specimens from St. Anthon's Colliery, Newcastle-upon-Tyne, by the Right Hon. Sir J. Banks. It would occupy too much space to mention all the collections that the Society has preserved, but among the donors are the well-known names of Sir Henry de la Beche, Sir Charles Lyell, Greenough, Warburton, and Sir Woodbine Parish. McEnery's collection that first brought Kent's Cavern into notice is there, and so is a splendid series of Daniel Sharpe's "Brachiopoda." The old red sandstone fishes presented by Lady Gordon Cumming are remarkable for their beauty as well as for the extent of the collection.

Many distinguished living geologists have private collections of their own; for example, the Earl of Enniskillen, Sir Philip Egerton, Prof. Prestwich, Mr. Searles Wood, Dr. Bowerbank, &c., which fully explains why their contributions are not so numerous as might be expected from the valuable work they have done. Prof. Phillips, though so energetic a worker, is not largely represented in the museum, for firstly York, and afterwards Oxford, had stronger claims on him. The same remark applies somewhat to the claims of the Woodwardian Museum on Prof. Sedgwick. As illustrating the geology of England generally, the Jermyn Street Museum and the British Museum are more useful, but as a record of early geological work the museum of the Society is unique.

The rearrangement of the foreign collections has not yet been completed, though it is in progress. Suites of specimens are to be seen there from all parts of the known world from which it has been possible for travellers to send them. These foreign collections are, to some extent, the result of contributions by officers in Her Majesty's services. Central Africa is not represented, but there are several collections from both coasts. For the future it is intended to add to the British collection only those specimens that are sent in illustration of papers read to the Society, but foreign specimens will be received as before.

Among the treasures of the museum, besides the rocks and fossils, there are the original drawings of Agassiz's "Poissons Fossiles," presented by the Earl of Enniskillen, the first manuscript geological map of England (1799), and the first table of strata, by W. Smith (1799).

The previous changes in the locality of the museum have

been as follows:—In No. 4, Garden Court, Temple, the first fixed habitation of the Society (June 1809), the collection was commenced. In June 1810 it was removed to 3, Lincoln's Inn Fields; in June 1816 to 20, Bedford Street; in the autumn of 1828, to Somerset House; at Somerset House it has remained till this last move to Burlington House.

CONDENSED AIR TRAMWAYS

FOR some weeks the North Paris Tramways Company has been trying on the line from Courbevoie to the Arc de l'Etoile a new system of locomotion, in which the motive power is compressed air. Some details of M. Mékarski's (the inventor) system are given in the *Revue Scientifique*. It is capable of considerable developments and of varied applications, since it has solved in a very satisfactory manner the double problem of the industrial production of air condensed to very high pressures, and of the storage of the air in reservoirs intended to discharge into a cylinder placed in any apparatus whatever, at any distance from the condensing pump.

The "Voiture Automatique" of M. Mékarski is characterised by the absence of an imperial and by a platform in front and another behind. This car carries the reservoirs of condensed air, the apparatus for distribution, and the cylinders. M. Mékarski places under the truck of the car the sheet-iron cylinders, which contain the condensed air; on the front platform is placed the distributing apparatus which the engine-man works; the two cylinders are placed, as in certain locomotives, outside the framework, horizontally, and act directly, by means of a crank, on the front wheels of the car. No doubt this arrangement might be advantageously modified; but the important point is the possibility of manufacturing compressed air in sufficient quantities to be of use as a motive power.

The condensing apparatus used by M. Mékarski consists of two pump-barrels of cast-iron, placed vertically, communicating respectively with two horizontal pump-barrels, in which move two pistons worked by a steam-engine. This is, in reality, a double condensing pump, the former bringing the air to the pressure of from ten to twelve atmospheres, and the second raising the pressure to twenty-five atmospheres. The pistons act upon a mass of water which compresses the air directly and absorbs by degrees the heat disengaged by compression. By an ingenious contrivance the supply of water is continually renewed, and the temperature thus kept down. But this arrangement does not absorb a sufficient amount of the heat disengaged, a difficulty which M. Mékarski has met as follows. The external air drawn into the pump raises a valve constantly covered by a layer of water of several centimetres; besides, a large cast-iron tube, constantly traversed by the air already condensed and the excess of water, communicates with the two vertical pump-barrels; finally, the second pump is fitted with a tap by which the heated water escapes.

In M. Mékarski's automatic car the compressed air is stored, under the truck, in sheet-iron reservoirs or cylinders. The total capacity is about 2,000 litres; 1,500 litres serve as an ordinary supply; 300 litres constituting a reserve; the remaining 200 litres are intended to serve as a brake. The air is compressed in the cylinders to the pressure of twenty-five atmospheres. On the line from Courbevoie to the Arc de Triomphe, 7,500 metres going and returning, the resistance is unusually great. In one experiment the ordinary feeding cylinders contained 1,500 litres of twenty-five atmospheres at departure, and the pressure, on arrival, was not more than four and a quarter atmospheres. The expenditure had thus been about 1,250 litres at twenty-five atmospheres for a run of 7,500 metres, or 166 litres per kilometre.

But unless it is possible to heat the air gradually

during its detention, and before it reaches the cylinder, unless, in fact, the heat abstracted in condensation be restored to it, the loss of power is very great. This has hitherto been the stumbling-block of compressed air engines, and M. Mékarski seems to have completely met the difficulty. He adopts as a re-heater a cylinder holding about 100 litres of water, taken from the boiler of an engine, at five atmospheres, and to obtain the maximum of effect possible, the condensed air is delivered from the reservoirs to the cylinder only after traversing the entire mass of water.

By a clever contrivance M. Mékarski regulates at pleasure the action of the compressed air upon the piston. Two hermetically-closed boxes are placed vertically upon the re-heater; their common face is formed by a caoutchouc diaphragm, in direct connection with an obturator, which opens or shuts more or less the opening which communicates between the lower box and the chamber containing a mixture of compressed air and vapour in the upper part of the hot-water cylinder. It will be seen that this orifice will be more or less uncovered according as the pressure in the lower box will be above, or not, the pressure in the lower box. This second box is itself filled with air, and constitutes a small pump-barrel, in which a large plunger piston works. The rod of the piston is a screw, and is fitted outside with a small regulator, on which the driver works. This may rapidly be made to vary the presence of the air in the upper box, and consequently the pressure be increased or diminished of the air which is delivered from the lower box to the motory cylinder.

THE GREAT TELESCOPE OF THE PARIS OBSERVATORY

WE have from time to time noted the progress of the great telescope which for years has been in course of construction for the Paris Observatory, and now that it is completed and in its place we are glad to be able to present a view of the instrument, for which, and for the details which follow, we are indebted to *La Nature*.

In 1855 M. Le Verrier purchased in England two large discs, the one of flint and the other of crown glass, intended to form the material for an object-glass. The late Léon Foucault, the eminent physicist of the Observatory, was charged with the investigation of the processes which should be employed to cut these large glasses, whose dimensions were much greater than those to which opticians had been accustomed. It is known how Foucault was led, by his series of investigations, to make mirrors of silvered glass. Successive attempts enabled him to present French observatories with reflectors of 40, of 50, and finally of 80 centimetres in diameter, having a tube in length only six times the diameter of the mirror. The largest of the telescopes constructed by Foucault himself, of 80 centimetres aperture, is at Marseilles, under the care of M. Stephan; by means of it this astronomer has seen all that Herschel saw with his enormous metallic reflector of 1.45 m. diameter, all that Lord Rosse has been able to see with his leviathan of 1.70 m., and he has added hundreds of new nebulae to the list given by his illustrious predecessors.

To crown his labours, L. Foucault wished to construct the largest mirror which it would be possible to make by his admirable method. This superior limit is 1.20 m. diameter. M. Le Verrier caused to be cast at St. Gobain a block of glass weighing 700 kilogrammes, which was rough-ground and shaped in the workshops of MM. Sauter and Lemonnier. But to construct this telescope, with its tube of 16 metres in length, required special funds, the ordinary budget of the Observatory not being sufficient. M. Le Verrier sought to obtain them from the Corps Législatif, which, in 1865, voted a sum of 400,000 francs.

By the beginning of 1868, Foucault, notwithstanding

his researches on regulators and the fatigue caused by the active part he took in the Exposition of 1867, had prepared the plans for the large reflector, when death snatched him from his work, and deprived France of one of the most original and finest geniuses she has possessed. This fatality, and the troubles which soon after and for long disturbed the Observatory, seemed to have lost to the country the work of years, and to have rendered useless the liberality of Government. Happily, the Minister of Public Instruction, M. Duruy, was willing to lend an attentive ear to the suggestions of men of science, and place at their service an intelligence eager for progress. At the request of the friends of Foucault he ordered the work which had been begun to be continued, and the authorities of the Observatory eagerly complied with his orders. An eminent mechanic, M. Eichens, indicated to M. Le Verrier by the Grand Prize in Mechanics which he obtained at the Exposition of 1867, and by his construction of large instruments for the Observatory, received the order for the construction of the telescope. M. Adolphe Martin, whom Foucault had instructed in his methods and associated with himself in his optical undertakings, was charged with the polishing of the mirror. Finally, M. Le Verrier entrusted to one of the astronomers of the Observatory, M. Wolf, the general superintendence of the work.

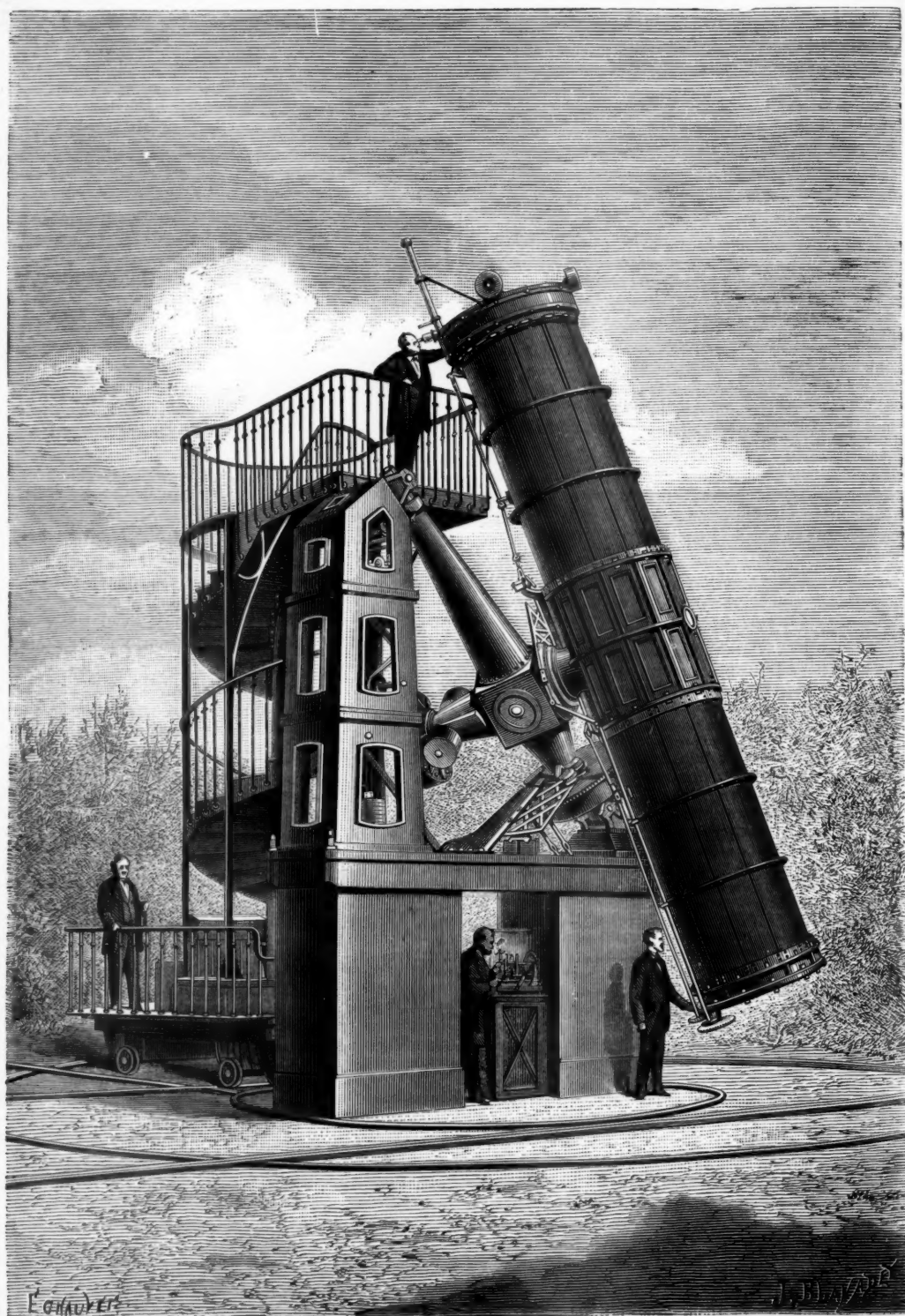
The construction ought to have been completed in three years. The war and the changes in the Observatory caused the work to languish, and it was not resumed with vigour until the return of M. Le Verrier as Director in 1873. At the commencement of 1875 the mirror was completed and tried upon terrestrial objects; M. Wolf had got a shelter constructed for the telescope and the staircase for the observer; finally, in the month of October, M. Eichens sent in the instrument complete in all its main details.

The total cost of the instrument and of the observatory amounts to 190,000 francs.

The illustration which we give represents the telescope in a position for observation. The wheeled hut under which it usually stands, a sort of wagon seven metres high by nine long and five broad, is pushed back towards the north along double rails. The observing staircase has been fitted to a second system of rails, which permit it to circulate all round the foot of the telescope, at the same time that it can turn upon itself, for the purpose of placing the observer, standing either on the steps or on the upper balcony, within reach of the eye-piece. This eye-piece itself may be turned round the end of the telescope into whatever position is most easily accessible to the observer.

The tube of the telescope, 7.30 metres in length, consists of a central cylinder, to the extremities of which are fastened two tubes of 3 metres long, consisting of four rings of forged iron bound together by twelve longitudinal bars also of iron. The whole is lined with small sheets of steel plate. The total weight is about 2,400 kilogrammes. At the lower extremity is fixed the barrel which holds the mirror; at the other end a circle, movable on the open mouth of the telescope, carries at its centre a plane mirror, which throws to the side the cone of rays reflected by the great mirror. The telescope is thus on the Newtonian system. That of Melbourne, so admirably constructed in England, is a Cassegrain telescope; the metallic mirror is pierced at its centre by an aperture which receives the eye-piece, a system so far advantageous that the observer always remains at the lower part of his instrument, and has to raise himself only a very short distance above ground, but less calculated perhaps to produce a perfect image than the Newtonian system adopted by Foucault.

The weight of the mirror in its barrel is about 800 kilogrammes; the eye-piece and its accessories have the same weight. Such is the load under which the tube of



THE NEW TELESCOPE OF THE PARIS OBSERVATORY. (From a Photograph.)

the telescope, suspended by its centre, must not bend more than a millimetre in the most unfavourable positions, according to the calculations by which M. Wolf determines its dimensions. Experience has verified his calculations; the two mirrors remain exactly centred upon each other in all positions of the telescope.

It is necessary, however, to be able to direct the tube toward any point of the sky, and it is necessary, moreover, that when the star is once in the field of the instrument, that should be able to follow it, by a simple movement, in its apparent course through the heavens. This is accomplished by what is called the *equatorial* mounting of the telescope. This revolves on an axis, cast of iron and steel, whose direction is parallel to the axis of the celestial sphere. Then it may be inclined more or less on this axis, by turning round in a second axis of steel, which crosses the former at a right angle, and partakes in its movement of rotation. The whole of the arrangement of double axes, a veritable wonder of mechanism, from the precision and ease of the movement, weighs with the telescope 10,000 kilogrammes. Such is the mass which, like the hand of a gigantic chronometer, must follow with precision the march of the stars in the vault of heaven, obedient to the action of clockwork, controlled by a Foucault regulator.

To realise this wonder, M. Eichens had to put together the most delicate apparatus of the mechanics of precision, and, preserving their delicacy intact, give them the strength necessary to support great weights. We cannot explain in detail the series of these wonders, tell how friction is almost annihilated throughout, how all the parts are in equilibrium, whatever be the position of the telescope: how, in fine, at the same time that the instrument follows the movement of the sky, the observer may at his pleasure move it with perfect ease in all directions by means of contrivances placed at his hand.

The perfection of mechanism would be nothing if it did not serve the purpose of observing the stars with an optical apparatus of equal perfection. Let us at once say that the first attempts which have been made with the instrument have completely satisfied the astronomers. Not only has the mirror acquired, under the hand of M. Martin, the rigorously parabolic form which gives it the property of collecting in a single point the rays of a star, but the very complex eye-piece, by means of which the luminous point is observed, is itself without a single defect. It now only remains to silver the surface of the mirror, an operation at present easy, by the processes of M. Ad. Martin, and which will be accomplished in a large dish 1.30 metres in diameter. Meantime, the surface of the polished glass reflects sufficient light to make it possible to observe the most feeble stars; directed towards the moon, the telescope concentrates in the eye a light almost intolerable. It may be judged from this what will be the brilliancy of celestial images when the silvered mirror will throw upon the eye, not merely scarcely one-half, but more than nine-tenths of the light which it receives.

The comparison which we made above between the Marseilles telescope of 0.80 metre aperture and the most powerful instruments elsewhere, allows us to predict the results which science has a right to expect from a telescope whose mirror is greater by half, and whose mechanism has reached the latest limits of perfection. M. Wolf, to whom the use of the telescope has been entrusted, proposes to employ it in observing the planets and their satellites. At the same time the new telescope will be fitted with all the apparatus necessary for photography and the spectroscopic observation of the stars. It should be remembered, however, that the use of such a gigantic instrument requires a long apprenticeship; the Melbourne instrument had two observers before it came into the hands of an astronomer who knew how to make good use of it.

costs of packing, sending, and returning any objects that may be confided to its care."

In a few weeks will be completed the first of the great instruments promised to France by MM. Le Verrier and Foucault. The construction of the telescope has been undertaken first, that it may serve as a study for the construction, much more delicate, of the great refractor of 16 metres in length, with an object-glass of .75 metre aperture. The success of the reflector is a guarantee that M. Le Verrier, with his eminent colleagues, will accomplish satisfactorily the second part of his great and patriotic enterprise.

THE LOAN EXHIBITION OF SCIENTIFIC APPARATUS AT SOUTH KENSINGTON

ON the 3rd inst., as we have already intimated, Her Imperial Highness the Crown Princess of Germany invited to her palace forty of the representatives of science of Berlin, to lay before them the plan of the London Exhibition of Scientific Apparatus, and to ask their co-operation for this purpose. Amongst those honoured by invitations were the Ministers of Education and of Commerce, the Postmaster-General, and the following professors of the University:—MM. Braun (botanist), Dove, Helmholtz, and Kirchhoff (physicists), Du Bois-Reymond (physiologist), Kiepert (geographer), Förster (astronomer), Peters (zoologist), Kronecker (mathematician), Websky (mineralogist), Hofmann, Oppenheim, and Sell (chemists), Wichelhaus (technologist), Orta (agriculturist); the following professors of the Polytechnic School:—MM. Reulaux (mechanician), Liebermann (chemist), Vogel (photographer), and Scheibler (agricultural chemist); the director of the South Kensington Museum, Mr. Cunliffe-Owen, the directors of the German Industrial Museum, MM. Gruner and Lessing, the manufacturers, Dr. Werner Siemens (member of the Academy), and Dr. Martius. The illustrious hostess, as well as His Imperial Highness the Crown Prince, pleaded warmly for the worthy representation of Germany in the London Exhibition. Although the short time left for preparation, and the coincidence of the exhibition with that of Philadelphia, were generally felt as serious drawbacks, some of the men of science present taking the lead assembled the following day, when a general committee was formed under the presidency of Dr. A. W. Hofmann; with the view of forming special committees for the different branches of the exhibition, and of inviting one member of every German University and Polytechnic School to co-operate with them. An invitation to the men of science and the manufacturers of scientific apparatus has already been issued.

"Science," the invitation says, "being the common property of all nations, the exhibition of the appliances by which it is promoted partakes of an international character. The objects pursued by the English Commission in organising the Exhibition have in Germany also been recognised as worthy of attainment, and, in order to give an impulse in our Fatherland to German participation in the Exhibition, a Committee has been formed, at the special instance of the Crown Prince and Princess of Germany, which has been intrusted by the English Commission with the collection and selection of objects worthy of being exhibited."

The invitation then proceeds to detail the conditions of exhibition settled by the Science and Art Department, and concludes as follows:—

"The Exhibition of Scientific Apparatus in London essentially differs from the former Exhibitions, as it pays less regard to merely commercial interests, but keeps in view the higher aim of disseminating as widely as possible the knowledge of the different methods of science. In order to render full justice to this task, the British Government (Science and Art Department) will bear all the

The Minister of the Admiralty has promised to send every instrument which should appear suitable for the purpose. The Committee of the German Chemical Society have elected superintendents to procure a worthy representation of chemical apparatus and specimens of chemical compounds of scientific interest. It has been decided to address an invitation to the members of the society to send such specimens to Berlin, in order to form a systematical and uniform collection of rare and interesting chemicals.

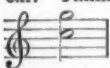
We may state generally that the Governments of Belgium, France, Germany, Italy, the Netherlands, and Switzerland, have now appointed committees to act in concert with the general committee in London. The Government of the United States has, through Mr. Fish, intimated that it is in communication with the various Departments and Scientific Institutions, with the object of forwarding the Exhibition.

BEATS IN MUSIC*

II.

THE second kind of beat differs from the first in that it arises from the imperfection, not of unisons, but of wide-apart consonances, such as the third, fourth, fifth, sixth, and octave.

This beat is well known practically to organ tuners, and may be soon rendered appreciable to any musical ear. Taking the fifth as an example, let the two notes



be sounded on an organ, or any instrument

of sustained tones. If they are perfectly in tune, the united sound will be smooth and even; but if one of them be sharpened or flattened a little, a beat will be heard just as in the case of the imperfect unison; and which, like it, will increase in rapidity as the note is made more and more out of tune. That this is not the same beat as Tartini's is obvious from the failure of the rule for the latter when applied to the former; for example, when the concord is in tune the upper note vibrates 768, and the lower one 512 vibrations per second, therefore there ought to be 256 beats per second; but in reality there are no beats at all, they only begin when the notes are put out of tune; hence the Tartini-beat rule is useless and inapplicable in this case.

This beat may be called the *consonance beat*, and it has also been termed "Smith's beat," from its having been first investigated by him.

The theory of Smith's beat, as given by Smith himself, is complicated and difficult to describe; but we will endeavour to give some idea of its nature and cause.

We must return to the illustration of the coffin-makers. Suppose one of them to have sold his business to another man in the trade, who was so much more active and energetic that he could drive his nails half as fast again as ordinary workmen. Call him A, and suppose that when he began to work it was found that he struck exactly three blows to two of his neighbour B. As B struck 100 per minute, A will now strike 150. And assume that on a certain day they both begin exactly together. The passer-by will hear that every third blow of A exactly coincides with every second of B; so that he will notice fifty coincidences in a minute; or to describe them more correctly, he will notice per minute fifty *phases of compound effects*, in each of which there is a coincidence. This phase constitutes *Tartini's beat*, but now very much augmented in rapidity from what it was before: then there were only one or two coincidences per minute, now there are fifty.

Now suppose that A, from some slight exhilarating

cause, begins to strike a little faster; i.e. that he makes 151 blows in a minute instead of 150. Let us endeavour to find out what will be the result on the listener. Still supposing the two strokes to begin with a coincidence, the third blow of A will still coincide *very nearly indeed* with the second of B; it will only differ from it by $\frac{1}{1500}$ of a minute, a quantity inappreciable to the ear. Hence the Tartini phase will at this time be practically unharmed. But after a few repetitions the divergence of the blows will be so great as to become appreciable, and the listener will begin to notice a series of *changes of form* of the Tartini phase, in which there is now *no coincidence* of the blows, but only a variation of their arrangement, which, moreover, is itself constantly varying. After a time, however, these changes will exhaust their possible varieties, the listener will notice that two of the blows begin to approach again, and at last will *coincide*, as they did before. He thus notices a *long cycle* of the Tartini beats, and this long cycle is the *Smith's beat*. It is, in fact, a beat of what mathematicians would call the second order; the first, or Tartini's beat, is a cycle of differing periods; the second, or Smith's beat, is a cycle of differing cycles.

Let us next attempt a numerical estimation of the length of this second cycle in the case of the coffin-makers. To effect this we must inquire when the coincidences of two blows will recur. It is plain that they will recur at the *end of the minute*, i.e. if the first blow of A coincided with the first of B, then the 151st of A will coincide with the 100th of B. This will give one long cycle, or one Smith's beat, per minute. A careful comparison of the times of the respective blows will show, moreover, that (since 100 and 151 are prime to each other) there will be *no other exact coincidence* during the minute; and a hasty reasoner may conclude that one beat per minute will be the proper number. But if the listener be asked to describe what he hears, he will dissent from this and say confidently that there are *two* places in the minute where he hears a coincidence. To test his assertion, let us apply Young's principle mentioned before, and inquire whether in the course of the minute there is any other place where the blows *so nearly* coincide that the ear may mistake them for real coincidences. The 74th blow of A will occur at $\frac{74}{151}$ of a minute after starting, whereas the 49th blow of B will occur at $\frac{49}{100}$ of a minute. The difference between these is only $\frac{1}{15100}$ of a minute, which is quite inappreciable. Hence, practically, there will be two parts of the minute where the blows coincide, and there will be consequently two Smith's beats in the same time.* If we were to suppose A to make 152 blows per minute (or 148, for a deficiency would produce the same result as an excess) to B's 100, we should, calculating on the above plan, find *four* cycles or beats per minute. Or we may alter the proportion: suppose for example, A, intending to make five blows to B's four, makes really 126 per minute instead of 125 as he ought to do; it will be found by calculation that there will be *four* places of coincidence in the minute, or four Smith's beats; if he strikes 127 blows, there will be eight Smith's beats—and so on.

We hope the foregoing homely illustration will help to render clear the nature of the Smith's beat as applied to sounds. Although the Tartini beat may not be really converted, as Young supposed, into the Tartini harmonic, but, according to Helmholtz, remains as a beat, inappreciable by reason of its great rapidity, it certainly has a physical and mathematical existence; and it as certainly changes its phases by reason of the small divergence of the times of vibration from those due to the true concord, and it is the recurrence of similar phases in a long cycle

* Mr. De Morgan, in his admirable paper elucidating Smith's profound investigation, unfortunately omits to notice this important element of the *approximate* coincidences. The consequence is that his explanation is not easy to follow, and indeed would *appear* wrong, although his results are perfectly correct.

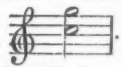
* By W. Pole, F.R.S., Mus. Doc. Oxon. Continued from p. 214.

which gives rise to the phenomenon in question. Smith contrived, with profound ability, to account for and calculate the beat independently of the Tartini beat, or whatever it may be called, but the introduction of this by De Morgan has wonderfully simplified the comprehension of the thing.

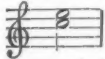
The accurate rule for finding how many beats per second will result from the concord being any given quantity out of tune; or for finding how much out of tune any concord is when it makes a certain number of beats per second, is remarkably simple.

Let n represent the denominator of the fraction, expressing, in the lowest terms, the true ratio of the concord (e.g. for the fifth $\frac{3}{2}$, $n = 2$; for the minor sixth $\frac{8}{5}$, $n = 5$, and so on); then let $q =$ the number of vibrations per second either in excess or deficiency of the number which would make the interval perfectly in tune; also let $\beta =$ the number of Smith's beats per second:

$$\begin{aligned} \text{then } \beta &= nq, \\ \text{or } q &= \frac{\beta}{n}. \end{aligned}$$

A few examples will show the easy application of these formulæ. Take the concord of the fifth, 

When this is true the upper note should make 768 vibrations per second to 512 of the lower one; but if it is tuned by equal temperament the upper note will be slightly flat, making 767.15. Hence $q = 0.85$; and as $n = 2$, we shall get $\beta = 1.7$, i.e. there will be 102 Smith's beats per minute.

Again, suppose we find the concord of the major third  give 120 beats per minute (= 2 per second), how much is it out of tune? As in this case $n = 4$, we have

$$q = \frac{\beta}{n} = \frac{1}{2};$$

i.e. the upper note vibrates half a vibration per second either more or less than it ought to do.

The number of beats per second due to imperfections in the various consonances will be as follows, q being always the number of vibrations by which the upper note is untrue:—

Tartini's Beats.

For the unison $\beta = q$.

Smith's Beats.

For the unison or octave	$\beta = q$.
"	"	fifth	...	$\beta = 2q$.
"	"	fourth	...	$\beta = 3q$.
"	"	major third	...	$\beta = 4q$.
"	"	minor third	...	$\beta = 5q$.
"	"	major sixth	...	$\beta = 3q$.
"	"	minor sixth	...	$\beta = 5q$.

In the case of the *unison*, the Tartini beat and the Smith beat are synonymous, and this identity is the reason why so many writers on beats have gone wrong; they have so often taken unison sounds as the easiest and simplest for popular illustration, and have either assumed, without further investigation, that the same principles would apply for other consonances also, or have omitted notice of the other consonances altogether.

It will now be easy to understand why beats are capable of such great utility in a practical point of view—namely, as giving a means of measuring, with great ease and positive certainty, the most delicate shades of adjustment in the tuning of concordant intervals. To get, for example, an octave, a fifth, or a third perfectly in tune, the tuner has only to watch when the beats vanish, which he can observe with the greatest ease, and which will give him far more accuracy than he could possibly get by the ear alone. Whereas if he desires to adopt any fixed

temperament, he has only to calculate the velocity of beats corresponding to the minute error which should be given to each concord, and the required note may be tuned to its proper pitch with a precision and facility which would be impossible by the unaided ear.

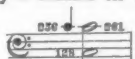
The delicacy of this method of tuning would hardly be believed, if it did not rest on proof beyond question. To recur to our example, the difference between 95 and 100 beats per minute would be appreciable by anyone with a seconds watch in his hand; and yet this would correspond to a difference of only $\frac{1}{100}$ of a vibration per second, or in pitch less than $\frac{1}{1000}$ of a semitone!

This use of beats has been long practised by organ-tuners to some extent, but its capabilities, as amplified by the aid of calculation, are certainly not appreciated or used as they ought to be.

The third kind of beat is what we may call the *overtone* beat, and was brought into prominent notice in 1862 by Helmholtz, who uses it for important purposes in regard to his musical theories.

It is known that nearly all musical sounds are compound; they consist of a fundamental note, which is usually the strongest (and by which the pitch of the note is identified), but which is accompanied with several fainter and higher *harmonic* notes, or, as Helmholtz calls them, *overtones*. The first of these is an octave above the fundamental, the second a twelfth above, the third a fifteenth, the fourth and fifth seventeenth and nineteenth respectively, and there are others still higher which we need not mention here. The number and strength of the overtones vary for different kinds of sounds, but the five lowest ones are very commonly present and distinguishable. Now, suppose we sound two notes, having such a relation to each other that any of the overtones of one will come within beating distance either of the other fundamental, or of any of its overtones, then a beat will be set up, which is the kind of beat now in question.

A few examples will make this clear. The bass fundamental C shown by a minim in the following example,

has its overtone  an octave above, as

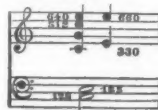
shown by the crotchet. Now if another fundamental C be sounded an octave above the former one, as the second minim, and if it be a little out of tune, there will be a unison beat between it and the overtone of the first note. This is one of Helmholtz's beats, and the simplest of them.

Again, take an interval of a fifth; the fundamental notes being shown in minims in the following illustration, and their respective overtones in crotchets:—



Here, if the G is not a perfect concord with the C, the two G's in the treble staff will be also out of tune with each other, and a unison beat will ensue. This is another Helmholtz beat, and a little more complex than the last, as both the beating notes are overtones.

Again, take an interval of a major third, expressing the notes and such of their respective overtones as we require in the same way as before, thus:—



Here, if we suppose the fundamental E to vibrate 165

instead of 160, *i.e.* five vibrations too sharp, the two upper E's in the treble stave will clash, and a beat will result.

In all these three cases Smith's beats also will naturally be present, and it is curious that in each case when we come to determine the rapidity of the beats, we find it come out the same, whether we calculate it by Smith's formula or by the unison beats of Helmholtz's overtones. We have added the vibration-numbers to the notes, to facilitate the calculation, and we find the number of beats per second to be—

For the imperfect octave	= 5
For the imperfect fifth	= 10
For the imperfect major third	= 20

each arising from a sharpness of five vibrations in the upper note of the concord.

Hence we may lay it down as a principle that in consonances slightly out of tune, the beat given by the two fundamentals on Smith's plan, and those given by the first corresponding overtones on Helmholtz's principle, are synchronous, and may be considered identical.

The two kinds of beats, however, must not be confounded, as their cause is so distinct. The Helmholtz beats arise from the overtones only, whereas Smith's explanation applies to the fundamental notes, independently of the overtones altogether.

Helmholtz notices (Ellis's translation, pages 302-3) that beats of consonances will occur when sounded by simple tones, but accounts for them in another and very ingenious way, namely, by calling in the aid of the *grave harmonics*, or, as he calls them, the *combination tones*.

Taking our first example of the octave consonance given above, when the two notes of 128 and 261 vibrations are sounded together, they will give rise to a combination tone of 123 vibrations, and this, clashing with the 128 note, will give beats at the rate of five per second.

For the next example, the consonance of the fifth, this explanation will not suffice, and Helmholtz has to resort to a cause of the second order, namely, the beat of a grave harmonic, not with an imperfect unison, but with an imperfect octave. Taking our former example, an out-of-tune fifth C and G, of 128 and 197 vibrations respectively; these two notes will give a combination or difference tone of 69 vibrations, or an octave below the C, but out of tune. Then Helmholtz says this lower C will beat with its imperfect octave, on account of a new or second order of difference-tones formed from them, as in the former case.

In a similar but still more remote way, Helmholtz accounts for the beats of other consonances, the fourth, third, &c.

Without questioning the sufficiency of these explanations, I must say they seem to me somewhat far-fetched, and less satisfactory than Smith's, which account for the beats by a more positive and direct method, without calling in the aid of any sounds but the simple fundamental ones. There is at any rate the satisfaction that whichever explanation be adopted, the numerical value of the number of beats per second comes out the same and agrees with the fact; so that in a practical point of view it is immaterial which explanation be adopted.

I have alluded above to one important practical use of beats, namely, in tuning; but there is another use of them, also very interesting, *i.e.*, that they furnish a means of ascertaining the positive number of vibrations per second corresponding to any musical note. This may be done either by the unison or by Smith's beat, and I will give both methods.

For the unison beat:—Take two notes in unison on an organ, a harmonium, or other instrument of sustained sounds, and put one of them a little out of tune, so as to produce beats when they are sounded together. Let V and v represent the vibration numbers of the upper and lower notes respectively. Then by means of a mono-

chord it will be easy to determine the ratio $\frac{V}{v}$, which call

m . Count the number of beats per second, which call β . Then, since $\beta = V - v$, we obtain the simple equation,

$$v = \frac{\beta}{m - 1}$$


which gives the actual number of vibrations per second of the lower note of the two.

The method of deducing the vibration-number from the Smith's beat was pointed out by Smith himself; but as this method, so far as I know, is not to be found anywhere, except buried under the mass of ponderous learning contained in his work; I give it here in a simple algebraical form. If $\frac{m}{n}$ represents the true ratio of the interval, N the actual number of vibrations per second of the lower note, and M the same number for the upper one, the formula for Smith's beats becomes


$$\beta = \left(m - n \frac{M}{N}\right) N; \quad \text{or } N = \frac{\beta}{m - n \frac{M}{N}}$$

Now, as m and n are both known for any given concord, if we can tell by any independent means the actual ratio of the notes $\frac{M}{N}$, we may, by simply counting the beats, calculate the actual number of vibrations N of the lower note. If the interval is too flat, β must be +; if too sharp, it must be -.

The following example will show how this may be done. Let it be required to determine how many vibrations per

second are given by the note  on an organ.


Tune three perfect fifths upwards, and then a perfect major

sixth downwards, thus—, which

will give the C an octave above the original note. But, by the laws of harmony, we know that this octave will not be in tune; the upper C will be too sharp, the ratio being $\frac{81}{40}$, instead of $\frac{2}{1}$, as it ought to be. Hence $\frac{M}{N} = \frac{81}{40}$,

and $\frac{m}{n} = \frac{2}{1}$. Count the beats made by this imperfect octave, and suppose them = 192 per minute, or 3.2 per second; then, as the interval is sharp,

$$N = \frac{-3.2}{2 - \frac{81}{40}} = 128;$$

i.e. the note  is making 128 double vibrations per second.

This method has the advantage of dispensing with the use of the monochord, which was necessary in the former case.

NOTES

A METEOROLOGICAL Commission, appointed by the Ministers of Public Instruction, Agriculture and Commerce, Marine, and Public Works, to inquire into the possibility and practicability of a more intimate co-operation being effected among the various meteorological systems of Italy, have just issued their report. The Commission consisted of fourteen members, including most of the well-known meteorologists of Italy, with Prof. Cantoni as president, and Prof. Pittel as secretary, and met daily at Palermo from Aug. 30 to Sept. 6, 1875. The more important of the conclusions arrived at are these:—That all methods of observing at the stations of the various systems connected with the State be

brought into accordance with those adopted by the Minister of Agriculture and Commerce; that harmonious action be based on the number, quality, and hours of the observations, a preference being given to those stations which from their position will best meet the requirements of local and international meteorology; that the instruments and modes of observing be strictly uniform; that inspection of stations be made at least once every two years, and that the reduction and publication of meteorological results be remitted to a directive council composed of meteorologists elected from the directors of the principal observatories and meteorological institutes, whose decisions will be carried out by a secretary and suitable staff.

At the meeting of the Paris Academy of Jan. 10, General de Nansouty submitted a report on the project of a physical observatory on the top of the Pic du Midi de Bigorre, Pyrenees. As our readers know, a small hotel on the Col de Sencours has been provisionally used for observations since 1873, but amid great difficulty, from avalanches, cold, &c. The Pic is 2,877 metres high, and only 527 short of the highest, but is easily accessible.

The Observatory on the Puy de Dôme is being rapidly completed, and will be opened this year. A semaphoric system of telegraphy will be used to keep the Observatory in constant communication with Clermont, the chief town of the district, at the foot of the mountain.

The fourth part of the second series of Mr. William H. Edwards' work on the Butterflies of North America has just been published by Hurd and Houghton, and contains five quarto plates of butterflies, drawn with the utmost excellence by Miss Peart. The forms illustrated are species of *Argynnis*, *Grapta*, *Melitæa*, and *Papilio*, most of them new species recently described by Mr. Edwards himself.

An addition to the list of American scientific journals has been made in the form of a *Botanical Bulletin*, edited by Mr. John M. Coulter, of Hanover, Indiana. At present it is a sheet of four pages, appearing monthly, with the promise of increase in size with increase in subscribers. It is in form and general scope much like the Bulletin of the Torrey Botanical Club.

DR. HOFMANN of Berlin has been elected a foreign associate of the Italian Society of Science in room of the late Sir Charles Wheatstone. This Society was founded in 1782; the Italian members are limited to forty, and at present the Society has only twelve foreign associates, among whom are Sir George Airy, Prof. Cayley, and Sir Edward Sabine. Its rules are numerous, and somewhat stringent.

THE Paris Academy of Sciences at Monday's sitting nominated Prof. Nordenskjöld a Correspondant in the section of Geography and Navigation.

THE Central Section, or governing body of the Geographical Society of Paris, has appointed as its president for 1876 M. Malte-Brun, the son of the celebrated Danish geographer.

THE Geological Society of Paris has elected as its president for 1876 M. Pellat, an amateur geologist, holding a high position in the finance department of Government.

THE warlike habits of the Papuans and their implements of warfare are described in a private letter recently addressed to Dr. Hooker. The writer says that no man leaves his dwelling for his bit of cultivation even without his powerful bamboo bow and a few deadly poisoned arrows. These poisoned arrows are only a few amongst a great number not poisoned, the former being distinguished by elaborate carving and painting, probably to prevent accident amongst themselves. They are each pointed and barbed with human bone brought to almost needle-like sharpness, most carefully and neatly finished; they are poisoned by

plunging in a human corpse for several days. Poor Commodore Goodenough and his men suffered from arrows so poisoned. It is a sort of blood-poisoning that, like other kinds of inoculation, does not develop itself for several days, the slightest scratch being sufficient to render almost inevitable a horrible death. The symptoms are accompanied by violent spasms like tetanus, with consciousness until the last.

CAPTAIN MORESBY'S work on New Guinea and Polynesia will be published shortly by Mr. John Murray. It will include discoveries and surveys in New Guinea and the D'Entrecasteaux Islands, a cruise in Polynesia, and visits to the pearl-shelling stations in Torres Strait of H.M.S. *Basilisk*, and will be illustrated by a map and wood-cuts. It will be interesting to compare this book of Captain Moresby's with Captain Lawson's "New Guinea," noticed in NATURE some time back.

M. E. QUETELET has called attention to the cold experienced in Brussels in December, 1875, when the temperature fell to freezing every night from 25th Nov. to 6th Dec., falling on the 2nd to 18°·5, which is lower than has occurred any time up to the 4th December, during the last forty-two years. In thirteen out of the forty-two years the temperature observations present a relation somewhat analogous to those of 1875. It is remarkable that with this low temperature and a persistent E.N.E. wind, the barometer has continued low and the air humid and constantly cloudy. On the 7th December the temperature fell to 5°·9.

PROF. F. W. PUTNAM, Dr. Packard's late colleague, the *Nation* announces, has been appointed Civilian Assistant on the U.S. Surveys west of the 100th meridian conducted by Lieut. G. W. Wheeler, and is already occupied in preparing a report on the abundant and very valuable archeological and ethnological material collected by the exploration in Arizona, New Mexico, and California. The report will be profusely illustrated, and the *Nation* ventures to predict, will be the beginning of our scientific knowledge of the prehistoric civilisation of the above-named regions.

A CONVOCATION of the University of London was held on Tuesday, at which, after a long discussion, a resolution was passed affirming the desirability of obtaining a new charter, and declaring that no such charter would be acceptable to convocation which did not enable the University to grant degrees to women.

THE Ladies' Classes at University College, London, began on Monday last the second term of their eighth session. There was a slight decline in the number of students for the session 1874-75, but the first term of the session 1875-76 showed a considerable advance beyond the highest success hitherto attained. In the Michaelmas term, 1874-75, the whole number of individual students was 199; in the Michaelmas term, 1875-76, just elapsed, the number of individual students was 265. The whole number of tickets taken in Michaelmas term, 1874-75, was 257; in the same term of 1875-76 it was 367.

IN a paper on the Chalk in the Channel district read at the Paris Academy on Monday, Prof. Hebert stated that he expected great obstacles to be met with in the attempt to bore a Channel tunnel.

IT is announced that all communications and notifications in connection with the next International Congress of Medical Sciences, to be held at Geneva on Sept. 9, 1877, be sent to the Committee before June 1, 1876, the time when the Committee will definitely settle the regulations and programme, and appoint reporters. The present president is Prof. C. Vogt, and the secretary Dr. T. L. Prevost.

M. ADOLPHE PICTET, who died at Geneva on Dec. 20 last, at the age of 76 years, was one of the most eminent writers on

ethnology and comparative philology of the present century. In 1839, the French Institute awarded him the Volney Prize for his work on the affinity of the Celtic Languages with Sanscrit. In 1853, this same prize was awarded him a second time for the publication of his great work, "Les Origines Indo-Européennes, ou les Aryas primitifs." M. Pictet was also an eminent man of letters. He was a corresponding member of the Royal Society of Edinburgh.

AN ingenious toy, apparently of Japanese origin, has recently been introduced into London. It consists of a small picture, on paper, of an individual pointing a firearm at an object—bird, target, or second person. By the application of the hot end of a match, just blown out, to the end of the gun, the paper commences to smoulder towards the object aimed at, and in no other direction. When it is reached a report is heard from the explosion of a small quantity of fulminating material. The toys are sold in London by Mesdames Jinks and Ashton, of Glasshouse Street.

ABOUT midnight on the 22nd of December, 1875, two earthquake shocks were felt at Washington, Richmond, Weldon, North Carolina, U.S., and other places in that section. There were two distinct shocks at Richmond, the first continuing about ten seconds, while the other was briefer and not so severe, and was accompanied by a concussion in the air.

THREE distinct shocks of an earthquake are stated to have been felt at Comrie, near Crieff, Perthshire, on Sunday—two at about three in the morning and the third in the afternoon.

THE *Gazette d'Augsbourg* states that a commission which has been visiting the Russian Universities has laid its report before the Czar. The chief recommendations are to increase the salaries of some of the professors, and to create a few new chairs.

THERE are several important papers in this month's part of Petermann's *Mittheilungen*. The editor himself takes occasion, on the conclusion of the new edition of Stieler's fine Hand-Atlas, to give a brief history of that work, and to point out the great advances in geography since the last edition was published. The first part of a paper appears, giving some account of Przewalsky's travels in Mongolia and the land of the Tanguts during 1870-73. We believe the author's narrative of this important expedition is being translated into English; a map accompanies the article in the *Mittheilungen*. A translation from the Russian gives an interesting description of the ruins of Mestorjan, in the Turkoman steppes. Some account of the Paris Geographical Congress is given by the delegates from Perthes establishment. A valuable paper by Dr. G. Hartlaub describes the great amount of work done by that indefatigable traveller in China, the Abbé Armand David. Along with a brief summary of discovery in the interior of Australia there is a fine map, showing the routes of Warburton, Forrest, and Giles.

SUPPLEMENT No. 44 of Petermann's *Mittheilungen* contains the first part of a narrative of the expedition which, under the engineer Josef Cernik, in 1872-73, explored the region of the Euphrates and Tigris, for the purpose of estimating its industrial capacities, and to mark out a route for a railway. The narrative will be found to contain much valuable information on the various aspects of the region visited. We need hardly say the narrative is accompanied by admirable maps.

THE Japanese Government is said to have adopted a singular method for extending a knowledge of the Arabic numerals with their English names; these are printed on cloth, which is sold at a low price to the peasantry.

THE *Annuaire* of the Bureau des Longitudes for 1876 was published a few days ago with an unusual number of useful tables and a map showing the magnetic declination for all French towns.

M. WALLON, the French Minister of Public Instruction, has abolished the fees of the several examiners in the degree examinations in Law, Medicine, Science, Literature, and Theology. The salaries of the professors and fellows have been raised on a scale varying from 6,000 francs to 18,000 francs, the professors of theology excepted. It is believed that these reforms are preparatory to the gratuitous conferment of degrees, which will be instituted by the new assembly.

WE have received the "Transactions" of the Clifton College Scientific Society, vol. ii. part 1, including the period from Dec. 1872 to June 1875. There are a number of very fair papers, though it seems to us that the members generally need to be wakened up and urged to attempt to rival similar societies in some of our other public schools. The "Transactions," however, contain one paper which alone reflects great credit on the Society, and especially upon its author, R. A. Montgomery. The paper is on the Isle of Unst, in Shetland, and describes, from personal observation, its geology, natural history, antiquities, and scenery, in a manner which would entitle it to a place in the "Transactions" of a more ambitious society. The paper is illustrated by maps and a section.

AN important publication has lately been commenced in the form of a Bulletin of the U.S. National Museum, consisting of a series of memoirs illustrating the collections of the museum. It is printed, by direction of the Secretary of the Interior, at the Government printing-office, from materials prepared by the Smithsonian Institution, which, as is known to our readers, has charge of the museum referred to. The first number of the *Bulletin* consists of a check list of the North American batrachia and reptilia, with a systematic list of the higher groups, and an essay on geographical distribution, as based on the specimens in the National Museum, and as prepared by Prof. Edward D. Cope, the well-known herpetologist and naturalist. The list of species is the first systematic enumeration of American reptiles since the time of Dr. Holbrook, and embraces 101 species of frogs, toads, salamanders, &c., 132 of serpents, 82 of lizards, 41 of turtles and tortoises, and 2 of crocodiles. Each species is accompanied by a reference to some work where it is described or figured. The list of the higher groups embraces those of the whole world, and will form a convenient basis for the arrangement of such collections in public museums.

THE scientific expedition, commanded by M. Mouchez for the survey of the coast of Algeria, will last ten months. During the latter part of the expedition M. Mouchez will resume the exploration of coral reefs, and will be accompanied by M. Lacaze-Duthiez.

MR. J. CLIFTON WARD has reprinted from the *Quarterly Journal* of the Geological Society his paper "On the Granitic, Granitoid, and Associated Metamorphic Rocks of the Lake District."

THE tenth edition of the Prospectus of Sir Joseph Whitworth's Scholarships for Mechanical Science has been issued, containing the papers set at the examinations in May 1875.

ON the 26th of November last, in the French island La Réunion, near Mauritius, a part of a mountain slipped down, seventy-two persons having been crushed by the falling rocks.

THE additions to the Zoological Society's Gardens during the past week include an Emu (*Dromæus nova-hollandia*) from Australia, presented by Mr. E. J. Dawes; a Palm Squirrel (*Sciurus palmarum*), a Manyar Weaver Bird (*Ploceus manyar*), two Nutmeg Birds (*Munia undulata*), two Amaduvade Finches (*Estrela amadava*) from India, presented by Mr. W. D. Baker; a Cinereous Sea-Eagle (*Haliaeetus albicilla*), European, deposited.

SCIENTIFIC SERIALS

THE current number of the *Journal of Anatomy and Physiology*—the second under the new system—commences with a paper by Dr. G. Thier and Mr. J. C. Ewart, entitled "A Contribution to the Anatomy of the Lens." The fibres of that organ are stated to be composed of a number of flattened bands, termed primary fibres, and to be covered with elongated flat cells resting on a structureless membrane.—Dr. McIntosh describes the central nervous system, the cephalic sacs, and other points in the anatomy of the *Lineidæ*, demonstrating that in the *Nemerteans* the nervous system is highly developed, and that the cephalic sacs are special organs of sense, their internal surface being in direct communication with the surrounding water by the ciliated duct, whilst the fibrous peduncle places their cells in continuity with the central nervous system. The paper is profusely illustrated.—Prof. Rutherford, who has been assisted by M. Vignal, records his experiments on the biliary secretion of the dog. In almost every case the animal had fasted about eighteen hours. Under the influence of curare a tube was tied into the bile duct. The amount of bile which flowed in each quarter of an hour was measured. The cholagogue action of croton oil is shown to be nil; that of podophylline considerable; that of aloes powerful; that of rhubarb well marked; that of senna feeble; that of colchicum considerable, by making the bile watery; that of taraxacum very feeble; that of scammony feeble; that of calomel probably nil; that of gamboge nil; that of castor-oil nil. The memoir, with its valuable diagrams, deserves special attention.—Dr. Galabin contributes an article on the pulse-wave in the different arteries of the body. The author, we are glad to see, has modified his previous statement as to the modification of a double wave the result of a single impulse, in the explanation of the predicrotic undulation in the sphygmograph trace. He gives an explanation of this as well as of the predicrotic wave. Some of his arguments are, we think, based on too few facts, whilst others are complicated by their pathological nature.—Mr. D. J. Cunningham has some notes on the broncho-oesophageal and pleuro-oesophageal muscles of man, first described by Hyrtl.—Dr. Stirling contributes a memoir on the summation of electrical stimuli applied to the skin, in which, from an excellent series of experiments on the frog, he demonstrates, according to the view of W. Bast, that *reflex movements can only be liberated by repeated impulses communicated to the nervous centres*.—Mr. F. M. Balfour commences a series of papers to ultimately constitute a monograph on the development of Elasmobranch Fishes. Commencing with the ripe ovarian ovum, its description is followed by that of the segmentation, in the volume before us. This monograph will be an invaluable adjunct to that on the hen's egg, by Dr. M. Foster and the same author, and is a most promising production of the Biological school of the University of Cambridge.—Prof. Huxley writes on the nature of the craniofacial apparatus of *Petromyzon*, a specially favoured region of that author. The plates are unfortunately delayed for three months.—Mr. S. M. Bradley has a note on the secondary arches of the foot.—Prof. Turner, lastly, gives a note on the placental area in the uterus of the cat after delivery, in which he shows that in delivery not all the mucosa of the placental area comes away, its deeper structures being partly left.—Prof. Turner and Mr. Cunningham's report on the progress of anatomy concludes the part.

Archives des Sciences Physiques et Naturelles, Oct. 15, 1875.—In this number is concluded an important paper by Prof. Lemström, of Helsingfors, on the theory of Aurora Borealis, *apropos* of some phenomena of Geissler tubes. The phenomenon from which he set out was that a Geissler tube is illuminated when near the pole of an electric machine, without the tube touching the poles. Air, at a pressure of 5 to 10 mm., acquires its maximum electric conductivity, and Prof. Lemström conceives the air in the upper regions of the atmosphere, rarefied to about 5 mm., as forming a great conductor concentric with the earth; its height some 3,000 kilometres less at the poles than at the equator, and the electric density (on both conductors) 9 per cent. greater, while the force with which the electricity of the atmospheric conductor is attracted to the earth is 42 per cent. greater (at poles than at equator). Thus there is accumulation of atmospheric electricity at the poles, and the auroras are produced on its combination with that of the earth. The theory regards aurora as a phenomenon entirely of our globe; but the possibility is not excluded of an action of the sun, causing a periodical variation of auroras, through meteorological phenomena, such as evaporation on the

earth's surface.—Prof. Schnetzler contributes some observations on Bacteria.—M. Cellerier investigates mathematically the simultaneous movement of a pendulum and its supports; and a *résumé* is given of the proceedings at the extraordinary session of the Geological Society of France, held in the end of August at Geneva and Chamounix.—In the "*Bulletin Scientifique*" there is a description of a curious phenomenon observed by M. Gumelius in Sweden, viz., intercrossing rainbows.

Journal de Physique, November, 1875.—This number contains the second part of M. de Romilly's paper on the conveyance of air by a jet of air or of vapour. He investigates the effects of the jet when driven against the lateral wall of the receiver, the orifices of the discharge-pipe and the receiver forming, if projected on a plane parallel to them, two circles exteriorly tangent. The form and separation of the two instruments are varied.—M. Angot, in another continued paper, gives a good account of Thomson's quadrant electrometer.—There are also short mathematical notes on the verification of the law of Huyghens, by M. Abrin; and elementary demonstration of the formula of La Place, by M. Lippmann, together with the usual amount of matter abstracted from other serials.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, Jan. 6.—On the Expansion of Sea-water by Heat. By T. E. Thorpe, Ph.D., and A. W. Rucker, M.A. (Fellow of Brasenose College, Oxford), Professors of Chemistry and Physics in the Yorkshire College of Science.

The extensive contributions which have recently been made to the physical history of the ocean have shown the desirability of exact knowledge of the relations of sea-water to heat. The authors have accordingly made observations in order to determine the law of the thermal expansion of sea-water.

The only attempt hitherto made to solve this problem which can lay any real claim to consideration is due to the late Prof. Hubbard, of the United States National Observatory. The results of his investigation are contained in Maury's "*Sailing Directions*," 1858, vol. i. p. 237.

Muncke, nearly fifty years ago, determined the expansion of an artificial sea-water at various temperatures between 0° and 100° C.; but our confidence in the results as applicable to natural sea-water is affected by the circumstance that the solution was prepared from data furnished by the imperfect analyses of Vogel and Bouillon La-Grange.

The observations of Despretz were confined to temperatures below 13°·27, as the main object of his inquiry was the determination of the point of maximum density of sea-water. The subsequent investigations of Neumann and Rossetti were equally limited, as they were undertaken with the same view.

The water used in the authors' observations was collected from the Atlantic, in lat. 50° 48' N. and long. 31° 14' W.; and its specific gravity at 0° C., compared with distilled water at the same temperature, was found by the bottle to be 1·02867.

The method of experiment was precisely the same as that already employed by one of the authors in determining the expansion of the liquid chlorides of phosphorus. It was essentially that already used by Kopp and Pierre; i.e. the expansion was observed in thermometer-shaped vessels (so-called dilatometers), graduated and accurately calibrated.

Three of these instruments and two sets of thermometers were employed. The latter were made by Casella; the length of a degree in different instruments varied between 9 and 13 millims.; they had been compared (the one set directly, the other indirectly) with Kew standards.

Three perfectly independent sets of observations were made with the water in the state in which it was collected; but as Mr. Buchanan, of H.M.S. *Challenger*, has found that the specific gravities of different sea-waters lie between the extreme values 1·0278 and 1·0240, and since, in order to be of value in the investigation of the physical condition of the ocean, the observations on their value and the formulæ of reduction ought to be correct to the fourth decimal place, quantities of the sea-water were diluted with distilled water, so as to have specimens of approximately the specific gravities of 1·020 and 1·025; and a third quantity was concentrated by evaporation until its specific gravity was increased to 1·033; two series of independent observations were made on the expansion of each solution.

Empirical formulæ were calculated to express the results of

each series of observations; and in the original paper full details of the observations are given, together with tables, showing the agreement between the calculated and observed results, and also (after the necessary corrections and reductions have been made) between the volumes calculated from the formulae from different series of observations in the same solutions.

Finally, a general formula of the form

$$v = \phi(t) + \psi(t)f(s)$$

was found, giving the relation between the volume (v), temperature (t), and specific gravity at 0° C. (s) of any solution of the same composition of sea-water the specific gravity of which at 0° C. lies between 1.020 and 1.033, the volume at the same temperature being taken as unity; in which expression

$$\phi(t) = 1 + .00008097t + .0000049036t^2 - .000000012289t^3,$$

and

$$f(s) = 11.95 - 940(s - 1.02).$$

In the original paper it is shown that if σ be the specific gravity at any temperature t and of a solution the specific gravity of which at 0° C. is s , $\frac{d\sigma}{ds}$ may without sensible error be assumed to be constant; whence, by means of the above formula, the authors are able to give in a table all the data necessary for calculating the specific gravity of sea-water of any degree of salinity at any temperature between 0° and 36° .

The authors conclude by discussing the discrepancies which occur between their results and those of Prof. Hubbard; and they point out various circumstances in the methods employed in making and reducing the latter observations which appear to them to explain in a great measure the divergences which exist.

On the Action of Light on Tellurium and Selenium. By Prof. W. G. Adams, F.R.S.

A small bar of tellurium, an inch long, whose resistance was half an ohm, forming part of one of the resistances in a Wheatstone's Bridge, was exposed to the light of a paraffin lamp at a distance of half a metre from it. At first, on exposure, the heat from the lamp increased the resistance of the tellurium.

When a rectangular vessel of water was placed between the lamp and the tellurium there was found, on exposing as before, to be no perceptible change in the resistance. On removing the rectangular vessel and putting a cylindrical beaker of water in its place, so as to focus the light on the tellurium, the resistance of the tellurium was found to be diminished.

When it had been kept in the dark for several days the tellurium was much more sensitive to light. When exposed to the paraffin lamp the resistance of the tellurium was now found to be as much diminished without using the beaker of water as it had previously been when the beaker was used. On introducing the beaker of water between the tellurium and the lamp, the resistance of the tellurium was still further diminished, the change produced in the resistance by the exposure being $\frac{1}{30}$ th part of the whole.

When the selenium bar was exposed to the same lamp at the distance of 1 metre, the change in the resistance was $\frac{1}{3}$ th of the whole.

On exposing the selenium to a constant source of light at different distances, the change in the resistance of the selenium is *inversely as the distance*, i.e., directly as the square root of the illuminating power.

The following results were obtained with one candle and an argand lamp, whose illuminating power is equal to sixteen candles:—

	At $\frac{1}{2}$ metre.	At $\frac{1}{3}$ metre.	At 1 metre.	At 2 metres.
With argand lamp	—	170	83	39
With 1 candle	—	41	18	8
With 1 candle	82	39	18	8

These and other similar experiments clearly show that the change in the resistance of the selenium is *directly as the square root of the illuminating power*.

Mathematical Society, Jan. 13.—Lord Rayleigh, F.R.S., vice-president, in the chair.—Major J. R. Campbell, Mr. R. P. Scott, and Prof. H. W. Lloyd Tanner were admitted into the Society.—The following communications were made:—Mr. J. W. L. Glaisher, F.R.S., on an elliptic-function identity.—Prof. H. W. Lloyd Tanner on the solution of partial differential equations of the second order with any number of variables when there is a complete first integral.—Prof. Clifford, F.R.S., on free motion of a rigid system in an n -fold homoloid;

expression of the velocities by Abelian functions.—The following abstract of Prof. Clifford's paper will give some idea of the mode of treatment employed:—Equations corresponding to Euler's are obtained for the $\frac{1}{2}n(n-1)$ rotations ρ_{hk} ; these are $\lambda_{hk}d_i\rho_{hk} = \sum \rho_{kl}\rho_{ki}$ where the λ are expressed in terms of the n constants a , namely, $\lambda_{hk}(a_h - a_k) = a_h + a_k$; it is understood that $\rho_{hk} = -\rho_{kh}$. It is then shown that similar equations are satisfied by quotients of θ -functions of $n-2$ arguments, one argument being $at + \epsilon$. The solution of the problem for the rotational velocities in n variables carries with it the determination of the position in the case of $n-1$ variables; the co-ordinates of the principal points are thus expressed in terms of the combinations of θ -functions which Rosenhain used for the inversion of integrals of the third class.—Lord Rayleigh, F.R.S., on the approximate solution of certain potential problems.

Royal Astronomical Society, Jan. 14.—Prof. Adams, president, in the chair.—A paper by the Astronomer Royal was read on the present state of his calculations for his new lunar theory.—Capt. Orde Browne read a paper on the times of the phenomena of the Transit of Venus. He compared the times given by the observers at the different Egyptian stations, and showed that the observations might be divided into three classes, in the first of which it seemed probable that the observers had noted as the time of internal contact the moment at which a shadowy ligament was first formed between the limbs of the planet and the sun. In the second class it appeared that the observers had noted as the time of internal contact the moment at which a black ligament, as dark or nearly as dark as the planet's disc, was first seen between the limbs of the planet and the sun; observers of the third class had waited for what he termed geometrical contact, or the moment when the discs of the planet and the sun appeared to have a common tangent. Mr. Burton said that the chief difficulty which he had experienced in noting the exact moment of internal contact at ingress arose from the bright line which was seen surrounding the dark limb of the planet before it entered upon the sun's disc, this prevented him from determining the moment when the solar cusps actually met around the disc of the planet.—Mr. Christie described a new form of solar eye-piece which he had devised. It consisted of a series of glass prisms placed between the eye-piece and the eye of the observer in such a manner that the light was reflected nearly at the polarising angle, and when the prisms were turned round relatively to one another, the intensity of the ray entering the eye could be adjusted with great nicety. The chief advantages of this plan were that by placing the prisms between the eye-piece and the eye the reflecting surfaces could be kept small and the eye-piece could be used as a photometer for comparing the intensity of very bright lights, as it was evident that the intensity of the reflected and emergent rays could be easily calculated directly the positions of the prisms were known.

Geological Society, Jan. 5.—Mr. John Evans, F.R.S., president, in the chair.—John Kenworthy Blakey, Frederick Hovenden, and Thomas Lovell, M. Inst. C.E., were elected Fellows of the Society.—The following communications were read:—Historical and personal evidences of subsidence beneath the sea, mainly if not entirely in the fourteenth and fifteenth centuries, of several tracts of land which formerly constituted parts of the Isle of Jersey, by Mr. R. A. Peacock, C.E.—In this paper the author brings forward a great number of details, derived in part from personal observations and in part from ancient documents, to prove that a considerable submergence of land has taken place round the island of Jersey within comparatively recent times. He referred principally to the existence of a submerged forest in the Bay of St. Ouen, evidenced by the existence of stumps of trees in the sea-bottom there, and by the traditional fact that up to quite a late period fees were paid for privileges connected with the forest of St. Ouen, although the forest itself had long previously disappeared beneath the sea. From the evidence it would appear that the submergence took place at the end of the fourteenth or the beginning of the fifteenth century. The author also noticed the occurrence of peat and submarine trees in the little bay of Grève de Lecq on the north side of Jersey, and especially referred to the evidence afforded by the Ecrehouis rocks and Maitre Isle, there having been in the latter a priory or chapel, supported by rents derived from the parish of Ecrehouis, which is now represented only by a small islet, with the ruins of an ecclesiastical building upon it, and a range of rocks protruding but little above the sea.—The physical conditions under which the Upper Silurian and succeeding Palaeozoic Rocks were probably

deposited over the Northern Hemisphere, by Mr. Henry Hicks. In this paper the author, after pointing out the lines of depression explained in his former paper to the Society, now further elaborated the views then propounded by him by carrying his examination into the higher Palæozoic series and into more extensive areas. Beginning at the top of the Lower Silurian, where he first recognises any evidence of a break in the Palæozoic rocks, he proceeded to show that this break was restricted to very limited areas, and almost entirely confined to the parts which had been first submerged, and where the greatest thickness of sediment had accumulated on both sides of the Atlantic, and hence where the pre-Cambrian crust had become thinnest. On the European side this break occurred where volcanic action had taken place, and has doubtless to be attributed to the combined action of upheaval of portions of the crust and the heaping up of volcanic material, the latter in some cases forming volcanic islets of considerable extent. He strongly objected to look upon these breaks, even in the British area, where they are most marked, as evidence of a want of continuity over other and far greater areas; or to admit that even where there was conformity in the rocks at this point, "great intervals of time are indicated, unrepresented by stratified formations." The conformity found in extensive and widely separated areas is proof also that a gradual contraction took place of an enormous portion of the crust in the northern hemisphere in Palæozoic times; and the breaks at the close of the Lower Silurian and in the Devonian are not indications of an arrest in the general subsidence. After indicating the changes which must have taken place in the climate from this gradual spreading of the water and the evidence to be derived from the consideration of the deposits and the faunas, the author drew the following general conclusions:—1. That the condition of the northern hemisphere at the beginning of Palæozoic time was that of immense continents in the higher latitudes, traversed by mountainous ranges of great height, but with a general inclination of the surface, on the one side (European) to the south-west and south, and on the other side (American) to the south-east and south. 2. That these continents were probably covered, at least in their higher parts, with ice and snow; and that much loose material had consequently accumulated over the plains and deeper parts, ready to be denuded off as each part became submerged. This would account for the enormous thickness of conglomerates, with boulders, grits, and sandstones, found in the early Cambrian rocks, and also to a certain extent for their barrenness in organic remains. 3. That the depression over the European and American areas was general from at least the latitude of 30° northwards; that the parts bordering the Atlantic were the first to become submerged; the lower latitudes, also, before the higher. 4. That the depression could not have been less altogether, for the whole of the Palæozoic, than 50,000 feet; and that conformable sediments to that extent are found over those parts of the areas first submerged, and which remained undisturbed. That volcanic action was chiefly confined to parts of the regions which became first submerged; that the immediate cause of these outbursts was the weakness of the pre-Cambrian crust at those parts, from the great depression that had taken place, it being too thin there to resist the pressure from within, and to bear the weight of the superincumbent mass of soft sediment. 5. That the seat of volcanic action at this time was at a depth of probably not less than twenty-five miles, as sediments which were depressed to a depth of from nine to ten miles do not indicate that they had been subjected to the effect of any great amount of heat, and are free from metamorphosis. 6. That the climate at the early part of Palæozoic time was one of very considerable, if not extreme cold, and that it became gradually milder after each period of depression. That towards the close of the Palæozoic, in consequence of the elevation of very large areas, and to a great height, the climate became again more rigorous in character. 7. That the various changes which took place over the northern latitudes during Laurentian and Palæozoic times allowed marine and land life to develop and progress in those areas at interrupted periods only; consequently most of the progressive changes in the life had to take place in more equatorial areas, where the sea-bottom was less disturbed, and where the temperature was more equable. Any imperfection, therefore, in the Palæontological record belonging to these early times should be attributed to these and like circumstances; for wherever an approach to a complete record of any part of the chain is preserved to us, the evidence points unmistakably to an order of development, through a process of evolution from lower to higher grades of life.

Anthropological Institute, Jan. 11.—Mr. A. W. Franks, F.R.S., vice-president, in the chair.—Messrs. H. A. Husband, E. Croghan, J. B. Lyons, and W. R. Cornish were elected members.—Mr. W. S. W. Vaux, F.R.S., read a paper on the Maori race of New Zealand. There were three sources from which some information as to the origin of the Maoris might be gained. Firstly, from traditions, among which a very general and remarkable uniformity prevails, pointing to the conclusion that the ancestors of the Maoris came from the north and north-east in small numbers and a few at a time, the names of some of the canoes in which they arrived having been preserved. The author thought that the evidence in favour of those traditions was conclusive. Secondly, from their ethnology and customs. With regard to the former, appearances were at first sight in favour of a mixed origin, the diversities in physiognomy and colour being considerable; but to that view the author thought the linguistic evidence furnished an unanswerable objection. As to the customs of the Maoris, they did not differ much from those found in other groups of Polynesian Islands, indicating a former intimate connection between them all. Thirdly, from language. The general conclusion of the author from that argument was that there was one Polynesian language which had been broken up into many dialects, the Maori being one. That opened out the larger question as to who the Polynesians were, and it was in that direction that inquirers must search for the origin of the Maoris. Evidence finally pointed to Asia for the solution of the problem.—Dr. Hector, F.R.S., exhibited and described at length the collection of stone and other implements he had recently brought from New Zealand, and went minutely into the circumstances of their discovery, their varieties, and uses. He also entered into a discussion on the traditions of the Maoris, their population in the two islands, their manners and customs, their language and physique, drew a comparison between them and the Moriories, and treated of many other topics relating to the past history and present condition of the people.

Physical Society, Jan. 15.—Prof. Gladstone, F.R.S., president, in the chair.—The following candidates were elected members of the society:—Sir David Lionel Salomons, Bart., Arthur R. Granville, and Capt. Abney, R.E.—Prof. Woodward, of the Midland Institute, Birmingham, exhibited and described a novel form of apparatus for showing either the longitudinal motion of sound-waves or the transverse vibrations of those of light. It consists essentially of a series of balls suspended in a horizontal line by strings. These balls rest against a series of transverse equidistant partitions in a wedge-shaped horizontal trough, which can be raised and depressed parallel to itself. If, while a ball is placed against each partition, the frame be drawn aside in the plane in which the balls hang, and then slowly depressed horizontally, the balls will be successively liberated, the order in which this takes place being regulated by the heights of the partitions. As these gradually increase from one end to the other, the appearance presented is that of a series of condensations and rarefactions, as in the ordinary acoustic wave. If the frame be drawn aside parallel to itself prior to depressing it, the balls will rest against one side of the trough and can be liberated in succession, causing them to oscillate in planes parallel to themselves. By this means a vibration of the particles is set up resembling that of polarised light.—Prof. Guthrie suggested that Mr. Woodward should devise a similar apparatus for exhibiting stationary waves.—Prof. Woodward said he would remember the suggestion, and stated that he had endeavoured to adapt the apparatus to circular and elliptic wave-motion, but experienced considerable difficulty.—Mr. Lockyer then made a communication on some recent methods of spectroscopy. At the outset he mentioned that he brought these processes forward in the hope that others present might be induced to take up some branch of the work. The first subject of which he treated was the photographing of the solar and metallic spectra. Mr. Rutherford, of New York, who has produced some of the finest photographs of spectra extant, has shown that to obtain clear photographs the smallest possible portion of the surface of the prism should be employed. An excellent method for ensuring this is to bring the light on the slit by means of a common opera-glass (as large as possible), which should reduce the beam of parallel rays incident on the prism to not more than a quarter of an inch in diameter. Mr. Lockyer exhibited the four-prism spectroscope employed by himself, to which a camera about four feet long is adapted. By this apparatus a large series of comparisons has been obtained between the sun and metals, the slit employed being provided with five slides, so that the spectra can be

accurately arranged side by side. It is advisable always to observe the image of the electric arc when comparing the spectra of metals with that of the sun, rather than direct light. It is also found very advantageous to place the poles of the lamp at right angles to the slit, as by this means the long and short lines in the spectra are more sharply defined than when observed in the ordinary manner. In the photograph comparing the spectra of aluminium and calcium it is noticeable that certain lines are common to the two, but those which are thick in the aluminium spectrum are thin in that of calcium, and *vice versa*. This depends on the quantities of impurity present. It has thus been shown that there are no proper coincident lines in the spectra of any two simple substances, and that there is no substance spectroscopically pure. The relation between the lengths of the lines and the amounts of metals employed to produce the spectrum convinced Mr. Lockyer that it would be possible to employ the spectroscope for quantitative analysis. The earlier experiments in this direction were then referred to, as well as those on which Mr. Lockyer has recently been engaged in conjunction with Mr. W. Chandler Roberts, of the Royal Mint, with a view to ascertain how far it is possible to detect small differences of composition in gold-copper alloys such as that used for the coinage. The method employed was then described. It consists in measuring, by means of a micrometer in the eye-piece of a four-prism spectroscope, the relative lengths of certain gold and copper lines when the image of an induction coil spark passing from the alloy under examination is focussed on the slit. Although the results obtained have not been uniformly comparable, and therefore reliable, it is nevertheless certain that a difference of composition as minute as the 1-333rd part is recognisable by this means. Another method of spectroscopic research which Mr. Lockyer next described was the study of the absorption spectra of metals when they are not subjected to so violent an action as that of the electric arc. Observations of this nature have been made at low temperatures by Roscoe and Schuster, and by Mr. Lockyer, and at the highest temperatures produced by the oxyhydrogen blow-pipe by the latter in conjunction with Mr. Roberts. These experiments, which have been fully described in the Proceedings of the Royal Society, show that the absorption spectra of metals may be divided into five classes, which, for any particular metals, depend on the amount of heat applied. They suggest that in passing from the liquid to the most perfect gaseous state, vapours are composed of molecules of different orders of complexity; and that this complexity is diminished by the dissociating action of heat, each molecular simplification being marked by a distinctive spectrum.—The President inquired whether the iridium line to which Mr. Lockyer had referred, and by means of which the metal was originally discovered, was absolutely identical with a hydrogen line.—Prof. McLeod asked if Mr. Lockyer had found that the incandescence of the air made any difference in the character of the spectra, and drew attention to the advantage of a small lens placed in front of the slit.—Mr. Woodward inquired whether any mechanical means were adopted for ensuring that the lamp gave a constant light while in the horizontal position.—Dr. Guthrie referred to the spectrum observed when light traverses the vapours resulting from the action of copper on nitric acid. He wished to know whether the number of bands observed stands in any relation to the number of possible oxides of nitrogen at a given temperature; or must one oxide of nitrogen be considered as being capable at that temperature of giving bright and dark bands according to the way in which the light acts on it?—Mr. Lockyer, in reply to the president's question, said that, so far, no difference has been observed between the refrangibility of the hydrogen line and that of iridium. He is anxious to ascertain whether any occluded hydrogen exists in the metal. Little or nothing is known as to the subject referred to in Dr. Guthrie's question. The use of the electric lamp eliminates all difficulty with reference to air lines, as its "atom-shaking" power is not sufficient to break up to the line stage the molecules of nitrogen and oxygen. It was found necessary to make the adjustments referred to by Mr. Woodward entirely by hand.

Victoria (Philosophical) Institute, Jan. 17.—On the Scientific Conclusions and Theological Inferences, in a recent work entitled "The Unseen Universe," was read by the Rev. Prebendary Irons, D.D., the Bampton Lecturer for 1870.

PARIS

Academy of Sciences, Jan. 10.—Vice-Admiral Paris in the chair.—The following papers were read:—Experimental critique

on the formation of saccharine matter in animals, by M. Cl. Bernard; an *aperçu* of his researches on the subject.—Researches on aldehyde, by M. Berthelot. He measures the heat liberated in transformation of aldehyde into acetic acid, and into oxalic acid, the heat of vaporisation, &c.—Union of carburets of hydrogen with hydracids and halogenic substances, by M. Berthelot.—Micrometric measurements taken during the transit of Venus, by M. Mouchez.—On the causes of failure in searching for minimal quantities of iodine, by M. Chatin.—New considerations on the regulation of slide valves, by M. Ledieu.—M. Mouchez presented some new maps of the coast of Africa.—Report on the project of a physical observatory on the top of the Pic du Midi de Bigorre, submitted to the Academy by General de Nansouty, in name of the Société Ramond. This peak (in the Pyrenees) is 2,877 metres in height, and only 527 short of the highest. It is somewhat isolated, and receives the direct shock of the great Atlantic air-currents; and it is easily accessible. A small hotel on the Col de Sencours (511 m. lower) has been provisionally used for observations since 1873, but amid great difficulty, from avalanches, &c.—Report on a memoir entitled "Problème inverse des brachistochrones," by M. Haton de la Goupillière.—Influence of tempering on magnetisation, by M. Gauguin. The bars hardened most are those which take the greatest magnetism, when one uses the most powerful means of magnetisation; but annealed bars are magnetised most powerfully where less energetic means are employed.—On the recent falling in on Bourbon Island, by M. Velain. The disaster was due to disaggregation of certain volcanic rocks under atmospheric agencies.—On a subterranean commotion in the centre of the isle of Réunion; disappearance of a hamlet of sixty-two persons, by M. Vinson.—On a pocket telemeter with double reflection, by M. Gaumet.—On the winter egg of Phylloxera, by M. Boiteau.—M. Carvalho presented a model of an ozonogenic apparatus, for rendering apartments wholesome in hot and unhealthy climates. It is a kind of condenser of the electric effluve. M. Thénard gave a warning on the poisonous action of ozone.—Generalisation of the theory of an osculating radius of a surface, by M. Lipschitz.—Note on a particular class of left decagons, inscribable by an ellipsoid, by M. Serret.—Note on the application of recurrent series to investigation of the law of distribution of primary numbers, by M. Lucas.—On the spectrum of gallium, by M. Lecoq de Boisbaudran. With chloride of gallium he gets two narrow lines, α 4170 and β 4031.—On the decrease of sugar in beets during the second period of their vegetation, by M. Cosenwinder.—On the installation of the Meteorological Observatory of the Puy de Dôme, by M. Alluard. Observations (every three hours) were commenced on Dec. 20, 1875. A station on the plain, at Clermont, 9 kil. distant, and 1,100 m. under the summit, is supplied with the same instruments, and the two stations are connected telegraphically.—On the periodic movements of leaves in *Abies nordmanniana*, by M. Chatin.

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